

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents  
United States Patent and Trademark  
Office  
Box PCT  
Washington, D.C.20231  
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 29 May 2000 (29.05.00)	
International application No. PCT/US99/20792	Applicant's or agent's file reference 30019.70WO01
International filing date (day/month/year) 10 September 1999 (10.09.99)	Priority date (day/month/year) 10 September 1998 (10.09.98)
Applicant MACNALLY, Donald, Evan et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:  
06 April 2000 (06.04.00)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was  
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Kiwa Mpay
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL SEARCH REPORT  
OR THE DECLARATION

To:

MERCHANT & GOULD  
Attn. Bruess, Steven C.  
3100 Norwest Center  
90 South Seventh Street  
Minneapolis, Minnesota 55402-4131  
UNITED STATES OF AMERICA

(PCT Rule 44.1)

ATY - RESP. SR

FEB 2, 2000

ATY - IDS DUE US

MAR. 3 - 2000

Date of mailing  
(day/month/year)

03/12/1999

Applicant's or agent's file reference

30019.70W001 ✓

FOR FURTHER ACTION

See paragraphs 1 and 4 below

International application No.

PCT/US 99/20792

International filing date

(day/month/year)

10/09/1999

Applicant

LEVEL ONE COMMUNICATIONS, INC. et al.

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

**Filing of amendments and statement under Article 19:**

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

**When?** The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

**Where?** Directly to the International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland  
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority



European Patent Office, P.B. 5818 Patentaan 2  
NL-2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Liliane Van Velzen-Peron

## NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

### INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

#### What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

#### When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

#### Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

#### How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

#### What documents must/may accompany the amendments?

##### Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

## NOTES TO FORM PCT/ISA/220 (continued)

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:  
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:  
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:  
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or  
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:  
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

### "Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

**It must be in the language in which the international application is to be published.**

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

### Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

### Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>30019.70W001</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/US 99/20792</b>	International filing date (day/month/year) <b>10/09/1999</b>	(Earliest) Priority Date (day/month/year) <b>10/09/1998</b>
Applicant <b>LEVEL ONE COMMUNICATIONS, INC. et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

## 1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☒ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1

☐ None of the figures.

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/20792

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 H04B1/30 H04B1/40

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 5 414 736 A (HASEGAWA MAKOTO ET AL) 9 May 1995 (1995-05-09) abstract column 1, line 1 -column 8, line 42 figure 19	5,6 1
A	US 5 757 921 A (OKANOBU TAIWA ET AL) 26 May 1998 (1998-05-26) abstract column 2, line 65 -column 4, line 19 figure 3 figure 4	1,4-6
A	US 5 355 524 A (HIGGINS JR ROBERT J) 11 October 1994 (1994-10-11) abstract figure 2 column 1, line 65 -column 2, line 60	1-3

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance  
"E" earlier document but published on or after the international filing date  
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)  
"O" document referring to an oral disclosure, use, exhibition or other means  
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention  
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone  
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.  
"&" document member of the same patent family

Date of the actual completion of the international search

29 November 1999

Date of mailing of the international search report

03/12/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Lindhardt, U

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/20792

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5414736 A	09-05-1995	JP 5048660 A	26-02-1993
		JP 2692440 B	17-12-1997
		JP 5048661 A	26-02-1993
		JP 5091151 A	09-04-1993
		EP 0527469 A	17-02-1993
		EP 0887978 A	30-12-1998
US 5757921 A	26-05-1998	JP 8265211 A	11-10-1996
		GB 2299226 A,B	25-09-1996
US 5355524 A	11-10-1994	WO 9314573 A	22-07-1993

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

Bruess, Steven C.  
MERCHANT & GOULD  
P.O. Box 2903  
Minneapolis, Minnesota 55402-0903  
ETATS-UNIS D'AMERIQUE

PCT

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT  
(PCT Rule 71.1)

Date of mailing  
(day/month/year) 04.01.2001

Applicant's or agent's file reference  
30019.70WO01

**IMPORTANT NOTIFICATION**

International application No.  
PCT/US99/20792

International filing date (day/month/year)  
10/09/1999

Priority date (day/month/year)  
10/09/1998

Applicant  
LEVEL ONE COMMUNICATIONS, INC. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

**4. REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/



European Patent Office  
D-80298 Munich  
Tel. +49 89 2399 - 0 Tx: 523656 epmu d  
Fax: +49 89 2399 - 4465

Authorized officer

Teschauer, B

Tel. +49 89 2399-8231





## PATENT COOPERATION TREATY

09/762720

PCT

NOTIFICATION CONCERNING  
SUBMISSION OR TRANSMITTAL  
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

From the INTERNATIONAL BUREAU

To:

BRUESS, Steven, C.  
Merchant & Gould P.C.  
3100 Norwest Center  
90 South Seventh Street  
Minneapolis, MN 55402-4131  
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 02 November 1999 (02.11.99)	<b>IMPORTANT NOTIFICATION</b>
Applicant's or agent's file reference 30019.70WO01	
International application No. PCT/US99/20792	
International publication date (day/month/year) Not yet published	
Applicant LEVEL ONE COMMUNICATIONS, INC. et al	

- The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
- This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.
- An asterisk(\*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
- The letters "NR" appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

<u>Priority date</u>	<u>Priority application No.</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
10 Sept 1998 (10.09.98)	60/099,723	US	01 Nove 1999 (01.11.99)

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer  Taïeb Akremi TA
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY 09/762720

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE  
COMMUNICATION OF THE INTERNATIONAL  
APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:

BRUESS, Steven, C.  
Merchant & Gould P.C.  
3100 Norwest Center  
90 South Seventh Street  
Minneapolis, MN 55402-4131  
ETATS-UNIS D'AMERIQUEDate of mailing (day/month/year)  
23 March 2000 (23.03.00)Applicant's or agent's file reference  
30019.70WO01

## IMPORTANT NOTICE

International application No.  
PCT/US99/20792International filing date (day/month/year)  
10 September 1999 (10.09.99)Priority date (day/month/year)  
10 September 1998 (10.09.98)Applicant  
LEVEL ONE COMMUNICATIONS, INC. et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:

US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:

EP

The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on 23 March 2000 (23.03.00) under No. WO 00/16492

**REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)**

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

**REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))**

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

J. Zahra

Telephone No. (41-22) 338.83.38

The demand must be filed directly with the competent International Preliminary Examining Authority. If two or more Authorities are competent, with the one chosen by the applicant. The full name and two-letter code of that Authority may be indicated by the applicant on the line below:

IPEA/ EP

09/762720

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:  
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty.

For International Preliminary Examining Authority use only

Identification of IPEA	Date of receipt of DEMAND
------------------------	---------------------------

<b>Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION</b>		Applicant's or agent's file reference 30019.70WO01	
International application No. PCT/US99/20792	International filing date (day/month/year) 10 September 1999 (10.09.1999)	(Earliest) Priority date (day/month/year) 10 September 1998 (10.09.1998)	
Title of invention  A SINGLE-CHIP CMOS DIRECT-CONVERSION TRANSCEIVER			
<b>Box No. II APPLICANT(S)</b>			
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)  LEVEL ONE COMMUNICATIONS, INC. 9750 Goethe Road Sacramento, California 95827 United States of America  (Applicant for all designations except US)		Telephone No.:	
		Facsimile No.:	
		Teleprinter No.:	
State (i.e. country) of nationality: US		State (i.e. country) of residence: US	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)  MACNALLY, Donald Evan 141 Bronte Street San Francisco, California 94110 United States of America  (Applicant for US designation only)			
State (i.e. country) of nationality: US		State (i.e. country) of residence: US	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)  CHO, Thomas B. 356 Oleander Avenue Alameda, California 94502 United States of America  (Applicant for US designation only)			
State (i.e. country) of nationality: US		State (i.e. country) of residence: US	
<input checked="" type="checkbox"/> Further applicants are indicated on a continuation sheet.			

## Continuation of Box No. II APPLICANT(S)

*If none of the following sub-boxes is used, this sheet is not to be included in the demand*

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

RABII, Shahriar  
Escondido Village, Quillen 3F  
Stanford, California 94305  
United States of America

(Applicant for US designation only)

State (i.e. country) of nationality:

US

State (i.e. country) of residence:

US

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

MEHTA, Srenik Suresh  
1468 8th Avenue  
San Francisco, California 94122  
United States of America

(Applicant for US designation only)

State (i.e. country) of nationality:

US

State (i.e. country) of residence:

US

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

NILSON, Christopher Donald  
170 South 14th Street  
San Jose, California 95112  
United States of America

(Applicant for US designation only)

State (i.e. country) of nationality:

US

State (i.e. country) of residence:

US

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

MACK, Michael Peter  
3114 Clay Street #1  
San Francisco, California 94115  
United States of America

(Applicant for US designation only)

State (i.e. country) of nationality:

US

State (i.e. country) of residence:

US



Further applicants are indicated on another continuation sheet.

## Continuation of Box No. II APPLICANT(S)

*If none of the following sub-boxes is used, this sheet is not to be included in the demand*

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

PLOUVIER, Laurence Marguerite  
141 Bronte Street  
San Francisco, California 94110  
United States of America

(Applicant for US designation only)

State (i.e. country) of nationality:

US

State (i.e. country) of residence:

US

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

MARRINGA, Menno  
25 Conrad Street  
San Francisco, California 94131  
United States of America

(Applicant for US designation only)

State (i.e. country) of nationality:

NL

State (i.e. country) of residence:

US

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

DUKATZ, Eric S.  
1012 Kirkham Street, Apt. 2  
San Francisco, California 94122  
United States of America

(Applicant for US designation only)

State (i.e. country) of nationality:

US

State (i.e. country) of residence:

US

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

State (i.e. country) of nationality:

State (i.e. country) of residence:



Further applicants are indicated on another continuation sheet.

**Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE**The following person is ☒ agent ☐ common representativeand ☒ has been appointed earlier and represents the applicant(s) also for international preliminary examination.☐ is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked.☐ is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*BRUESS, Steven C.  
MERCHANT & GOULD P.C.  
P.O. Box 2903  
Minneapolis, Minnesota 55402-0903  
United States of AmericaTelephone No.:  
612/ 336-4711Facsimile No.:  
612/ 336-4751

Teleprinter No.:

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.**Box No. IV STATEMENT CONCERNING AMENDMENTS**

The applicant wishes the international Preliminary Examining Authority \*

(i) ☒ to start the international preliminary examination on the basis of the international application as originally filed.(ii) ☐ to take into account the amendments under Article 34 of☐ the description (amendments attached).☐ the claims (amendments attached).☐ the drawings (amendments attached).(iii) ☐ to take into account any amendments of the claims under Article 19 filed with the International Bureau (a copy is attached).(iv) ☐ to disregard any amendments of the claims made under Article 19 and to consider them as reversed.(v) ☐ to postpone the start of the international preliminary examination until the expiration of 20 months from the priority date unless that Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

\* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

**Box No. V ELECTION OF STATES**☒ The applicant hereby elects all eligible States *(that is, all States which have been designated and which are bound by Chapter II of the PCT)* except .....*(If the applicant does not wish to elect certain eligible States, the name(s) or country code(s) of those States may be indicated above.)*

**Box No. VI CHECK LIST**

The demand is accompanied by the following documents for the purposes of international preliminary examination:

## 1. amendments under Article 34

description : sheets

claims : sheets

drawings : sheets

## 2. letter accompanying amendments under Article 34 : sheets

## 3. copy of amendments under Article 19 : sheets

## 4. copy of statement under Article 19 : sheets

## 5. other (specify): : sheets

For International Preliminary  
Examining Authority use only

received

not received

☐☐☐☐☐☐☐☐☐☐☐☐☐☐

The demand is also accompanied by the item(s) marked below:

1. ☐ separate signed power of attorney

4. ☒ fee calculation sheet

2. ☐ copy of general power of attorney

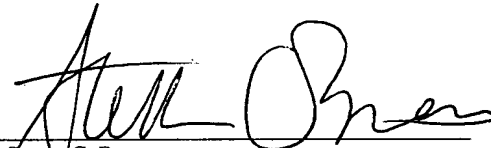
5. ☒ other (specify): Acknowledgement Form (1 sheet)

3. ☐ statement explaining lack of signature

**Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE**

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

By

  
Steven C. Bruess

For International Preliminary Examining Authority use only

## 1. Date of actual receipt of DEMAND:

## 2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):

3. ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply.

☐ The applicant has been informed accordingly.

4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.

5. ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

For International Bureau use only

Demand received from IPEA on:

09/762720

FD REC'D

MAY 11 2000

PCT

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

Bruess, Steven C.  
MERCHANT & GOULD  
P.O. Box 2903  
Minneapolis, Minnesota 55402-0903  
ETATS-UNIS D'AMERIQUE

NOTIFICATION OF RECEIPT  
OF DEMAND BY COMPETENT INTERNATIONAL  
PRELIMINARY EXAMINING AUTHORITY

(PCT Rules 59.3(e) and 61.1(b), first sentence  
and Administrative Instructions, Section 601(a))

Date of mailing  
(day;month;year)

05. 05. 00

Applicant's or agent's file reference  
30019.70W001

IMPORTANT NOTIFICATION

International application No.

PCT/US 99/ 20792

International filing date (day;month;year)

10/09/1999

Priority date (day;month;year)

10/09/1998

Applicant

LEVEL ONE COMMUNICATIONS, INC. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority considers the following date as the date of receipt of the demand for international preliminary examination of the international application:

06/04/2000

2. This date of receipt is:



the actual date of receipt of the demand by this Authority (Rule 61.1(b)).



the actual date of receipt of the demand on behalf of this Authority (Rule 59.3(e)).



the date on which this Authority has, in response to the invitation to correct defects in the demand (Form PCT/IPEA/404), received the required corrections.

3. ☐ **ATTENTION:** That date of receipt is **AFTER** the expiration of 19 months from the priority date. Consequently, the election(s) made in the demand does (do) not have the effect of postponing the entry into the national phase until 30 months from the priority date (or later in some Offices) (Article 39(1)). Therefore, the acts for entry into the national phase must be performed within 20 months from the priority date (or later in some Offices) (Article 22). For details, see the *PCT Applicant's Guide*, Volume II.



(If applicable) This notification confirms the information given by telephone, facsimile transmission or in person on:

4. Only where paragraph 3 applies, a copy of this notification has been sent to the International Bureau.

Name and mailing address of the IPEA:

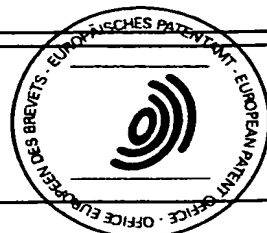


European Patent Office  
D-80298 Munich  
Tel. (+49-89) 2399-0, Tx: 523656 epmu d  
Fax: (+49-89) 2399-4465

Authorized officer

PITTORRU R

Tel. (+49-89) 2399-2403





PCT COOPERATION TREATY

09/762720

PCT

INFORMATION CONCERNING ELECTED  
OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

From the INTERNATIONAL BUREAU

To:

BRUESS, Steven, C.  
Merchant & Gould P.C.  
3100 Norwest Center  
90 South Seventh Street  
Minneapolis, MN 55402-4131  
ETATS-UNIS D'AMERIQUE

FFD REC'D

JUN 20 2000

Date of mailing (day/month/year) 29 May 2000 (29.05.00)		
Applicant's or agent's file reference 30019.70WO01		IMPORTANT INFORMATION
International application No. PCT/US99/20792	International filing date (day/month/year) 10 September 1999 (10.09.99)	Priority date (day/month/year) 10 September 1998 (10.09.98)
Applicant LEVEL ONE COMMUNICATIONS, INC. et al		

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE  
National :US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

None

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing, if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

The entry into the European regional phase is postponed **until 31 months from the priority date** for all States designated for the purposes of obtaining a European patent.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland  Facsimile No. (41-22) 740.14.35	Authorized officer:  Kiwa Mpay <i>KMP</i>  Telephone No. (41-22) 338.83.38
--	--

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

09/762720

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference

(if desired) (12 characters maximum) 30019.70WO01

Box No. I TITLE OF INVENTION

A SINGLE-CHIP CMOS DIRECT-CONVERSION TRANSCEIVER

Box No. II APPLICANT

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

LEVEL ONE COMMUNICATIONS, INC.  
9750 Goethe Road  
Sacramento, California 95827-  
United States of America

☐ This person is also inventor

Telephone No.

Facsimile No.

Teleprinter No.

State (that is, country) of nationality:  
US

State (that is, country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

MACNALLY, Donald Evan  
141 Bronte Street  
San Francisco, California 94110  
United States of America

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
US

State (that is, country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:

☒ agent

☐ common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

BRUESS, Steven C.  
MERCHANT & GOULD P.C.  
3100 Norwest Center  
90 South Seventh Street  
Minneapolis, Minnesota 55402-4131  
United States of America

Telephone No.  
612/ 336-4711

Facsimile No.  
612/ 336-4751

Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

## Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

*If none of the following sub-boxes is used, this sheet is not to be included in the request.*

Name and address *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

CHO, Thomas B.  
356 Oleander Avenue  
Alameda, California 94502  
United States of America

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State (i.e. country) of nationality:  
US

State (i.e. country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

RABII, Shahriar  
2162 Staunton Court  
Palo Alto, California 94306  
United States of America

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State (i.e. country) of nationality:  
US

State (i.e. country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MEHTA, Srenik Suresh  
1468 8th Avenue  
San Francisco, California 94122  
United States of America

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State (i.e. country) of nationality:  
US

State (i.e. country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

NILSON, Christopher Donald.  
170 South 14th Street  
San Jose, California 95112  
United States of America

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State (i.e. country) of nationality:  
US

State (i.e. country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on another continuation sheet.

**Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS***If none of the following sub-boxes is used, this sheet is not to be included in the request.*

Name and address *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MACK, Michael Peter  
3114 Clay Street #1  
San Francisco, California 94115  
United States of America

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State (i.e. country) of nationality:  
US

State (i.e. country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

PLOUVIER, Laurence Marguerite  
141 Bronte Street  
San Francisco, California 94110  
United States of America

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State (i.e. country) of nationality:  
US

State (i.e. country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MARRINGA, Menno  
25 Conrad Street  
San Francisco, California 94131  
United States of America

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State (i.e. country) of nationality:  
Netherlands

State (i.e. country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

DUKATZ, Eric S.  
1012 Kirkham Street, Apt. 2  
San Francisco, California 94122  
United States of America

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State (i.e. country) of nationality:  
US

State (i.e. country) of residence:  
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

**Box No. V DESIGNATION OF STATES**

The following designations are hereby made under Rule 4.9(a) (*mark the applicable check-boxes; at least one must be marked*):

**Regional Patent**

- ☐ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☐ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☐ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (*if other kind of protection or treatment desired, specify on dotted line*)

**National Patent** (*if other kind of protection or treatment desired, specify on dotted line*):

- |   |   |
|---|---|
| <input type="checkbox"/> AE United Arab Emirates                  | <input type="checkbox"/> LC Saint Lucia                               |
| <input type="checkbox"/> AL Albania                               | <input type="checkbox"/> LK Sri Lanka                                 |
| <input type="checkbox"/> AM Armenia                               | <input type="checkbox"/> LR Liberia                                   |
| <input type="checkbox"/> AT Austria and utility model             | <input type="checkbox"/> LS Lesotho                                   |
| <input type="checkbox"/> AU Australia                             | <input type="checkbox"/> LT Lithuania                                 |
| <input type="checkbox"/> AZ Azerbaijan                            | <input type="checkbox"/> LU Luxembourg                                |
| <input type="checkbox"/> BA Bosnia and Herzegovina                | <input type="checkbox"/> LV Latvia                                    |
| <input type="checkbox"/> BB Barbados                              | <input type="checkbox"/> MD Republic of Moldova                       |
| <input type="checkbox"/> BG Bulgaria                              | <input type="checkbox"/> MG Madagascar                                |
| <input type="checkbox"/> BR Brazil                                | <input type="checkbox"/> MK The former Yugoslav Republic of Macedonia |
| <input type="checkbox"/> BY Belarus                               | <input type="checkbox"/> MN Mongolia                                  |
| <input type="checkbox"/> CA Canada                                | <input type="checkbox"/> MW Malawi                                    |
| <input type="checkbox"/> CH and LI Switzerland and Liechtenstein  | <input type="checkbox"/> MX Mexico                                    |
| <input type="checkbox"/> CN China                                 | <input type="checkbox"/> NO Norway                                    |
| <input type="checkbox"/> CR Costa Rica                            | <input type="checkbox"/> NZ New Zealand                               |
| <input type="checkbox"/> CU Cuba                                  | <input type="checkbox"/> PL Poland                                    |
| <input type="checkbox"/> CZ Czech Republic and utility model      | <input type="checkbox"/> PT Portugal                                  |
| <input type="checkbox"/> DE Germany and utility model             | <input type="checkbox"/> RO Romania                                   |
| <input type="checkbox"/> DK Denmark and utility model             | <input type="checkbox"/> RU Russian Federation                        |
| <input type="checkbox"/> DM Dominica                              | <input type="checkbox"/> SD Sudan                                     |
| <input type="checkbox"/> EE Estonia and utility model             | <input type="checkbox"/> SE Sweden                                    |
| <input type="checkbox"/> ES Spain                                 | <input type="checkbox"/> SG Singapore                                 |
| <input type="checkbox"/> FI Finland and utility model             | <input type="checkbox"/> SI Slovenia                                  |
| <input type="checkbox"/> GB United Kingdom                        | <input type="checkbox"/> SK Slovakia and utility model                |
| <input type="checkbox"/> GD Grenada                               | <input type="checkbox"/> SL Sierra Leone                              |
| <input type="checkbox"/> GE Georgia                               | <input type="checkbox"/> TJ Tajikistan                                |
| <input type="checkbox"/> GH Ghana                                 | <input type="checkbox"/> TM Turkmenistan                              |
| <input type="checkbox"/> GM Gambia                                | <input type="checkbox"/> TR Turkey                                    |
| <input type="checkbox"/> HR Croatia                               | <input type="checkbox"/> TT Trinidad and Tobago                       |
| <input type="checkbox"/> HU Hungary                               | <input type="checkbox"/> UA Ukraine                                   |
| <input type="checkbox"/> IN India                                 | <input type="checkbox"/> UG Uganda                                    |
| <input type="checkbox"/> ID Indonesia                             | <input checked="" type="checkbox"/> US United States of America       |
| <input type="checkbox"/> IL Israel                                | <input type="checkbox"/> UZ Uzbekistan                                |
| <input type="checkbox"/> IS Iceland                               | <input type="checkbox"/> VN Viet Nam                                  |
| <input type="checkbox"/> JP Japan                                 | <input type="checkbox"/> YU Yugoslavia                                |
| <input type="checkbox"/> KE Kenya                                 | <input type="checkbox"/> ZA South Africa                              |
| <input type="checkbox"/> KG Kyrgyzstan                            | <input type="checkbox"/> ZW Zimbabwe                                  |
| <input type="checkbox"/> KP Democratic People's Republic of Korea |   |
| <input type="checkbox"/> KR Republic of Korea                     |   |
| <input type="checkbox"/> KZ Kazakhstan                            |   |

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

☐

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of

The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (*Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.*)

## Supplemental Box

*If the Supplemental Box is not used, this sheet should not be included in the request.*

1. If in any of the Boxes, the space is insufficient to furnish all the information: in such case, write "Continuation of Box No. ..." [indicate the number of the Box] and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient in particular:
- (i) if more than two persons are involved as applicants and/or inventors and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;
  - (ii) if, in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;
  - (iii) if in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;
  - (iv) if, in addition to the agent(s) indicated in Box No. IV, there are further agents: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;
  - (v) if in Box No. V, the name of any State (or OAPI) is accompanied by the indication "patent of addition," or "certificate of addition," or if, in Box No. V, the name of the United States of America is accompanied by an indication "continuation" or "continuation-in-part": in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;
  - (vi) if there are more than three earlier applications whose priority is claimed: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI.
  - (vii) if, in Box No. VI, the earlier application is an ARIPO application: in such case, write "Continuation of Box No. VI," specify the number of the item corresponding to that earlier application and indicate at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed.
2. If, with regard to the precautionary designation statement contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.
3. If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning non-prejudicial disclosures or exceptions to lack of novelty: in such case, write "Statement Concerning Non-Prejudicial Disclosures or Exceptions to Lack of Novelty" and furnish that statement below.

CONTINUATION OF BOX V.:  
60/099,723 10 September 1998 (10.09.98)

**Box No. VI PRIORITY CLAIM**☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country	regional application:* regional Office	international application: receiving Office
item (1) 10 September 1998 (10.09.1998)	60/099,723	US		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): (1)

\* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which the earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.

**Box No. VII INTERNATIONAL SEARCHING AUTHORITY**

**Choice of International Searching Authority (ISA)**  
(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):  
ISA / EP

**Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):**

Date (day/month/year):                      Number:                      Country (or regional Office):

**Box No. VIII CHECK LIST; LANGUAGE OF FILING**

This international application contains the following number of sheets:

request : 6  
description (excluding  
sequence listing part) : 16  
claims : 1  
abstract : 1  
drawings : 16  
sequence listing part  
of description :

Total number of sheets : 40

This international application is accompanied by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ Other (specify): Gen. Transmittal (in dupl)

Return Postcard

Figure of the drawings which  
should accompany the abstract: \_\_\_\_\_

Language of filing of the  
international application: English

**Box No. IX SIGNATURE OF APPLICANT OR AGENT**

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

By   
Steven C. Bruess

For receiving Office use only

1. Date of actual receipt of the purported international application:	2. Drawings:  <input type="checkbox"/> received:  <input type="checkbox"/> not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA/	
6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid	

For International Bureau use only

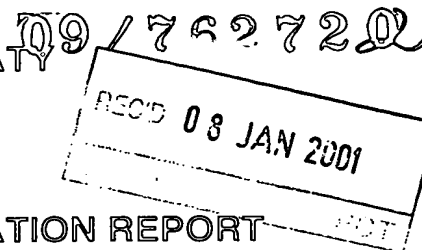
Date of receipt of the record copy  
by the International Bureau:

## PATENT COOPERATION TREATY

PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)



Applicant's or agent's file reference 30019.70WO01	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US99/20792	International filing date (day/month/year) 10/09/1999	Priority date (day/month/year) 10/09/1998
International Patent Classification (IPC) or national classification and IPC H04B1/30		
Applicant LEVEL ONE COMMUNICATIONS, INC. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 7 sheets, including this cover sheet.

- ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 19 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 06/04/2000	Date of completion of this report 04.01.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Giglietto, M Telephone No. +49 89 2399 8214 



# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US99/20792

## I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).):*

### Description, pages:

1,3-9,11-16	as originally filed			
2,10	as received on	27/09/2000	with letter of	10/09/2000

### Claims, No.:

1-6	as received on	27/09/2000	with letter of	10/09/2000
-----	----------------	------------	----------------	------------

### Drawings, sheets:

1/16-16/16	as received on	27/09/2000	with letter of	10/09/2000
------------	----------------	------------	----------------	------------

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/US99/20792

- ☐ the description,      pages:  
☐ the claims,      Nos.:  
☐ the drawings,      sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes:	Claims	1-4
	No:	Claims	5-6
Inventive step (IS)	Yes:	Claims	1-4
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-6
	No:	Claims	

2. Citations and explanations  
**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:  
**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

---

International application No. PCT/US99/20792

**Re Item V**

**Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Citations:

D1: US-A-5 414 736

D2: US-A-5 355 524

2. Claim 1 of the present application relates to a single chip transceiver.
3. The closest prior-art is considered to be D1 which is cited on page 2 of the description and discloses a receiver for FSK communications suitable for an integrated circuit comprising inter-alia a mixer, a baseband filter and a demodulator.
4. Problem: how to provide an improved transceiver which allows higher component integration and lower power consumption.
5. Solution: a direct conversion single chip transceiver in CMOS technology (see section VIII) using a TDD access scheme is proposed in claim 1 comprising inter-alia, in the receiver section, a mixer, a baseband filter implemented in switched-capacitor technique (see section VIII) connected at the output of the mixer, a demodulator connected at the output of the baseband filter and, in the transmitter section, an amplifier; the receiver and the transmitter are coupled to a single RF input/output port so that no TX/RX switch is required. The particular inventive combination of features is considered to be the use of the direct conversion technique, which does not require an IF filter at the output of the mixer but a simpler baseband filter, and the CMOS technology which a) allows the design of a switched-capacitor baseband filter and b) provides the advantage of saving a TX/RX switch at the antenna input by connecting both the receiver input and the transmitter output at the same RF combined input/output port.
6. These features of independent claim 1 are not known from any of the available prior-art documents nor are they rendered obvious thereby:

D1: merely relates to a receiver for FSK communications. D1 does not disclose a single chip CMOS transceiver including a power amplifier and a receiver both connected to an input/output port and does not suggest the use of TDD in combination with a switched-capacitor filter.

D2: discloses a transceiver for TDM communication using a TX/RX RF switch. No direct conversion is shown and therefore an external IF bandpass filter is still required.

Therefore, the subject-matter of claim 1 meets the requirements of Art. 33(2) and (3) PCT (but see clarity objection in section VIII of this Report).

The dependent claims 2-4 add further features to the independent claim 1 and thus also relate to novel and inventive subject-matter (but see section VIII about claim 2).

7. Claim 5, directed to a single-chip direct conversion receiver, also lacks clarity (see also section VIII), however, as far as can be understood, document D1 already shows a demodulation system suitable for an integrated circuit (cf. e.g. col. 3, lines 43-44, col. 30, lines 32-40 and Fig. 14), comprising an amplifier (cf. e.g. Fig. 14, 202), a mixer (cf. e.g. Fig. 14, 203), a baseband filter (cf. e.g. Fig. 14, 204) and a demodulator (cf. e.g. Fig. 14, 205, 206, 207, 210) wherein the baseband filter is coupled to the mixer and the demodulator is coupled to the baseband filter as recited in claim 5 of the present application.

The same features are also shown in Fig. 1 (the amplifier before the mixer is implicit) and in the description of the background art of D1 (cf. e.g. Fig. 22).

- 7.1 Since all the features of claim 5 are known from D1, the subject matter of **claim 5 lacks novelty** (Art. 33(2) PCT).
8. Dependent claim 6 does not contain any additional features which in combination with the features of any claim to which they refer, would satisfy the requirement of novelty since the feature of performing FSK modulation is already known from D1 (cf. e.g. col. 10, lines 31-41).

**Re Item VII**

**Certain defects in the international application**

1. The features of the claims are not provided with **reference signs** placed in parentheses (Rule 6.2(b) PCT).
2. Independent claim 1 is not in the **two-part form** in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art (document D2) being placed in a preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in a characterising part (Rule 6.3(b)(ii) PCT).

**Re Item VIII**

**Certain observations on the international application**

1. Claims 1 and 5 do not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined. The claims attempt to define the subject-matter in terms of the **result to be achieved** which merely amounts to a statement of the underlying problem (how to get a single chip direct conversion transceiver). The technical features necessary for achieving this result should be added.

From the description (cf. e.g. pages 11-12) it is apparent in fact that the integration results are obtained through the particular combination of TDD and selected CMOS circuit topologies which therefore should also be mentioned in the independent claims.

2. It is clear from the description on pages 7, 12 that the following features are essential to the definition of the invention:

(1) the circuit is implemented in CMOS technology (which allows a) the design of

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

---

International application No. PCT/US99/20792

excellent switches. Said switches are the basis for sampled-charge based design approaches; cf. e.g p. 7, lines 2-3; p. 8, lines 14-17; **b)** other technologies such as the bipolar would require also an antenna switch, cf. e.g. p. 11, l. 14-18);  
(2) the baseband filter is of a switched capacitor type.

Since independent claim 1 does not contain these features it does not meet the requirement following from Article 6 PCT taken in combination with Rule 6.3(b) PCT that any independent claim must contain all the technical features essential to the definition of the invention.

3. Claim 2 merely relates to a feature implicit in the TDD access scheme and does not add any feature to the transceiver of claim 1. Since the embodiment of claim 2 does not differ from that of claim 1, claim 2 is redundant and should have been deleted.

circuits, the level of integration in the RF sections of transceivers is still relatively low. Considerations of power dissipation, form factor, and cost dictate that the RF/IF portions of these devices evolve to higher levels of integration than is true at present. Nevertheless, there are some key barriers to realizing these higher levels of  
5 integration.

U.S. Patent No. 5,414,736 (D1) discloses an FSK data receiving system constituting a direct-conversion receiver suitable for realizing an integrated circuit. The system comprises a local oscillator with FSK-modulated local oscillator signals, and a decode circuit for judging the FSK-modulated frequency deviation of a carrier  
10 wave signal.

U.S. Patent No. 5,355,524 (D2) discloses a single chip receiver/transmitter section including an antenna switch (208), a low noise amplifier (210), a power amplifier (212), and first and second mixers (214, 216), on the single chip.

A high level of integration is critical in lowering the cost of electronics for  
15 communication systems such as cellular phones, cordless phones, and wireless LANs. Increasing levels of transceiver integration are being reported, e.g., RF, baseband analog, and mixed-signal circuits have been integrated. Further, RF, baseband analog, and voltage-controlled oscillator (VCO) circuits have also been realized in a single die.

20 It can be seen that there is a need for a fully-integrated transceiver.

It also can be seen that there is a need for a fully-integrated transceiver that incorporates RF circuits, synthesizer, baseband filters, demodulator, and extensive digital control functions.

#### SUMMARY OF THE INVENTION

25 To overcome the limitations in the prior art described above, and to overcome other limitations that will become apparent upon reading and understanding the present specification, the present invention discloses a single-chip CMOS direct-conversion transceiver.

In one embodiment of the present invention, the single-chip CMOS direct-  
30 conversion transceiver includes an RF circuit, a transmitter having a synthesizer,

a receiver having a baseband filter, and a demodulator. The synthesizer is coupled to the RF circuit. The baseband filter is coupled to the RF circuit and the synthesizer. The demodulator is coupled to the baseband filter. The RF circuit, the synthesizer,

5 response to the signal. This is accomplished by two main components of the architecture.

The first main component is the signal format. A signal format was chosen such that the I and Q base band signals exhibit a positive and negative peak within a certain time frame, 6.66 micro-seconds was chosen. The peaks and valleys of the I  
10 and Q signals from one time frame to the next are required to be approximately equal.

The second main component is a positive and negative peak detector which determines the peaks and valleys of the signal over a certain time frame (6.66 $\mu$ S). The offset is then the addition of the positive and negative peaks divided by two.

15 A fully-differential analog signal path minimizes supply and substrate noise coupling. To further reduce coupling, transitions of digital signals have been minimized near the sampling edge of baseband switched-capacitor circuits. Source-coupled logic has been utilized in the PLL frequency dividers to reduce substrate noise injection, while CMOS logic gates have been used in a burst-mode controller  
20 (BMC) 134 to achieve low power dissipation and high circuit density. An automatic calibration technique has allowed the integration of a 1.8-GHz LC VCO with a wide tuning range. The receiver 126 has a maximum gain of 106 dB and a sensitivity of -104 dBm.

A low noise amplifier (LNA) 138 and the power amplifier (PA) 140 designs  
25 make it possible to share a common RF port 136, thereby eliminating the need for an external transmitter/receiver switch. The transmitter 124 and receiver 126 are attached to the filter/antenna port of a radio transceiver without the need for a costly antenna switch in a time division duplex system.

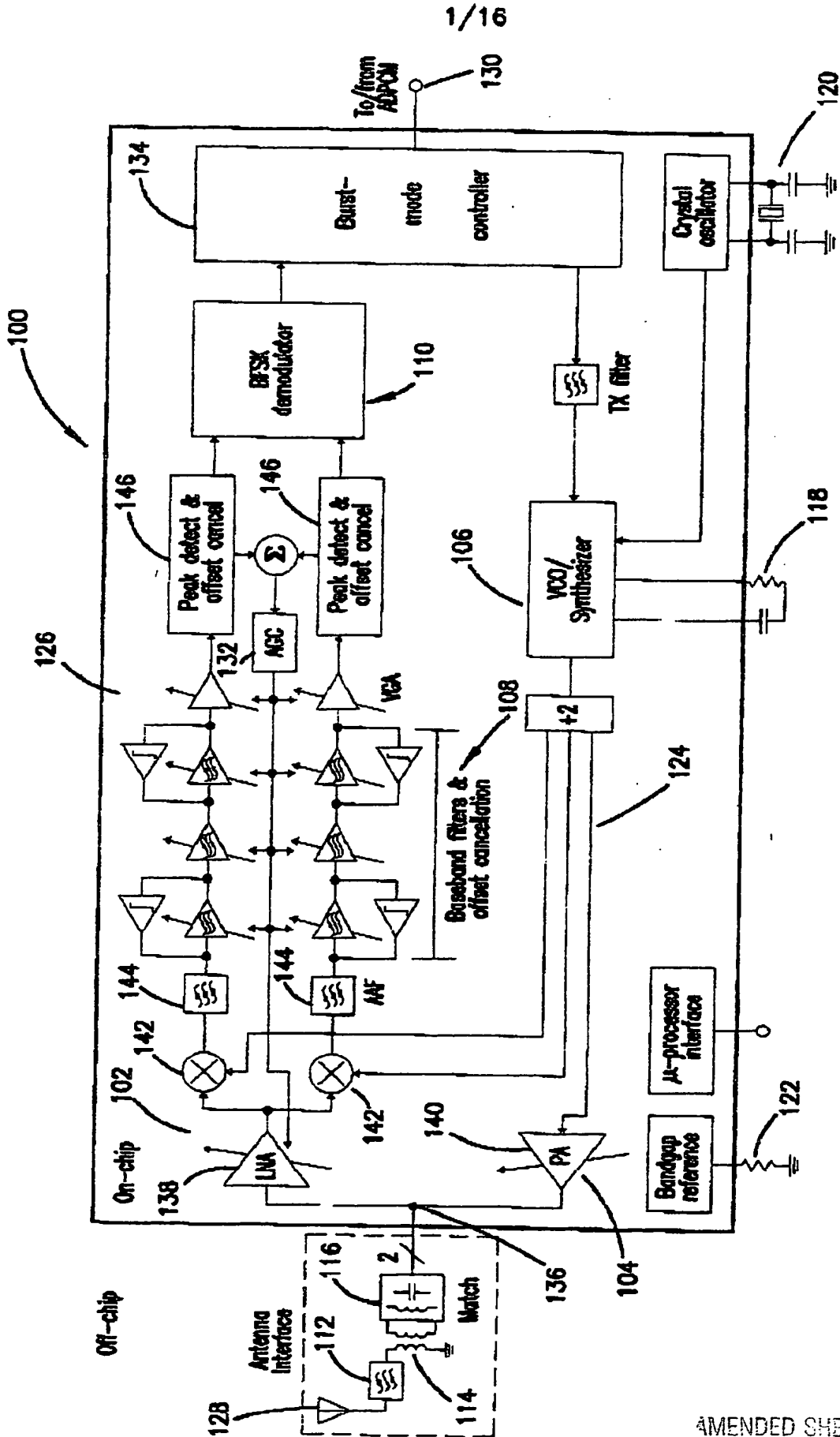
Radio transceivers usually require both a Low Noise Amplifier or (LNA) for  
30 clear reception and a Power Amplifier or (PA) for transmitting over long distances.

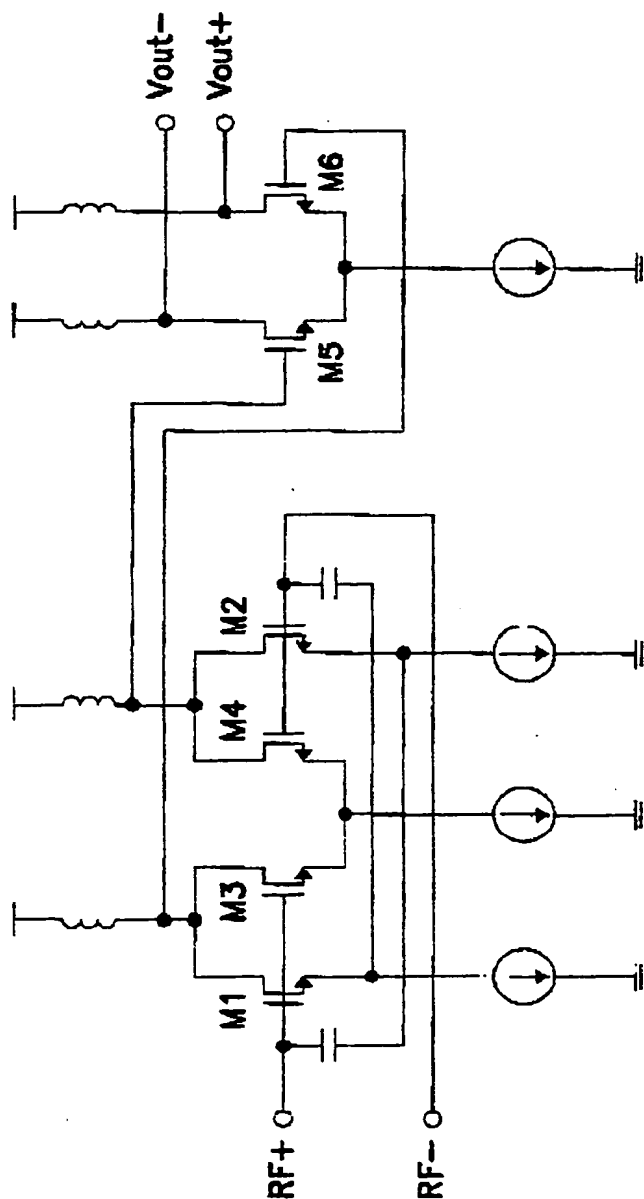


What is claimed is:

1. A single-chip direct conversion transceiver (100) in a time-division duplex (TDD) system, comprising:
  - a single RF combined input/output port (136);
  - a receiver (126) including: an amplifier (138) with an impedance transformation network having an input and output terminal, the amplifier input terminal being coupled to the RF input/output port (136);
  - a baseband filter (108) being coupled to the amplifier (138); and
  - a demodulator (110) being coupled to the baseband filter (108); and
  - a transmitter (124) including: a power amplifier (140) with a matched impedance network having an input and output port, the output port of the power amplifier being coupled to the RF input/output port (136); and a synthesizer (106) being coupled to the power amplifier (140).
2. The transceiver of claim 1, wherein the time-division duplex (TDD) ensures isolating between the receiver section (126) and the transmitter section (124).
3. The transceiver of claim 1, wherein the RF combined input/output port (136) interfaces with an external antenna.
4. The transceiver of claim 1, wherein the synthesizer performs FSK modulation.
5. A single-chip direct conversion receiver (126), comprising:
  - an amplifier (138) having an input and output terminal, the amplifier input terminal interfaces with an external antenna;
  - a mixer (142) having an input and output terminal, the mixer input terminal being coupled to the amplifier output terminal;
  - a baseband filter (108) being coupled to the mixer (142); and
  - a demodulator (110) being coupled to the baseband filter.
6. The receiver of claim 5, wherein the demodulator performs FSK modulation.

FIG. 1

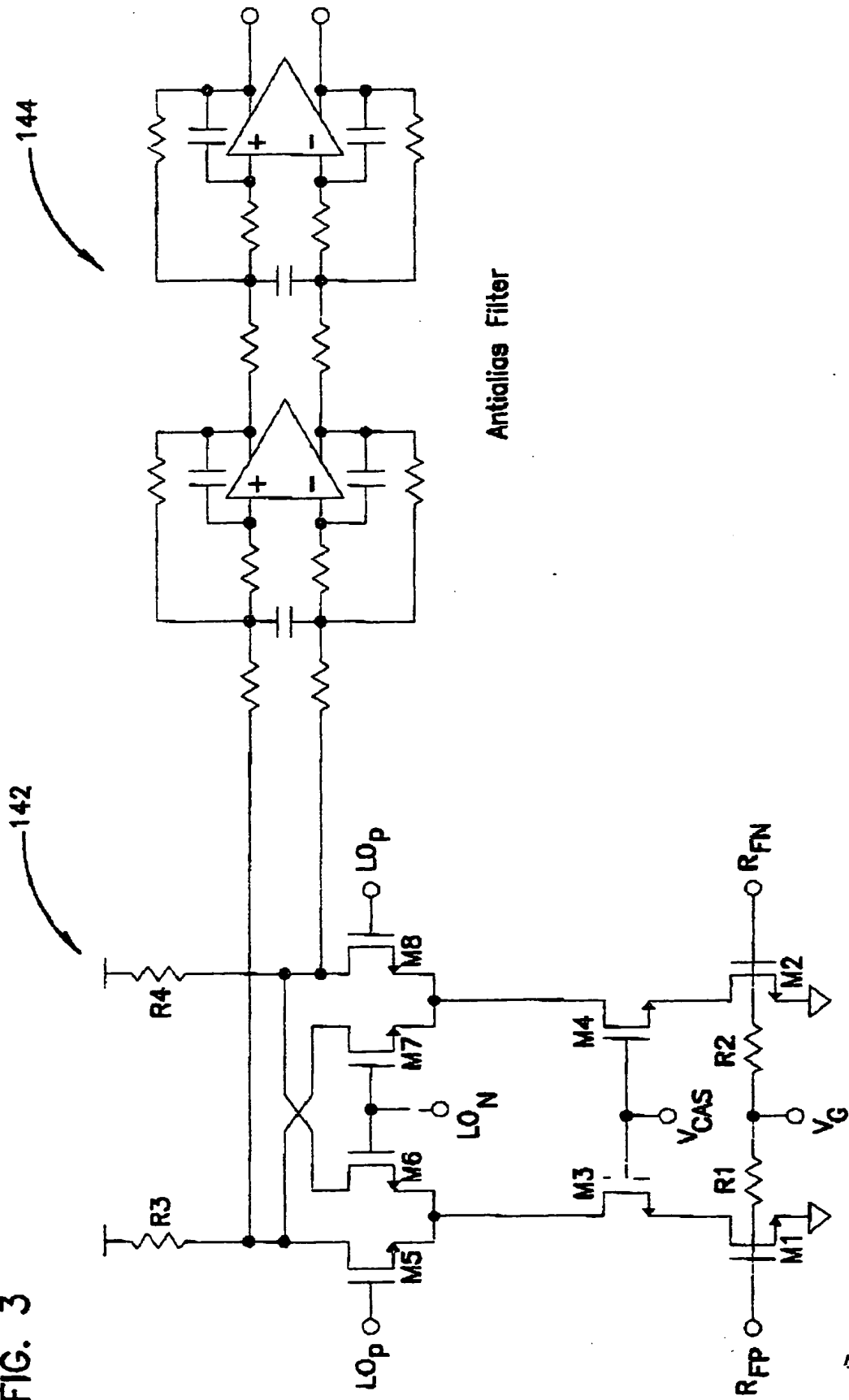




**FIG. 2**

3/16

FIG. 3



AMENDED SHEET

4/16

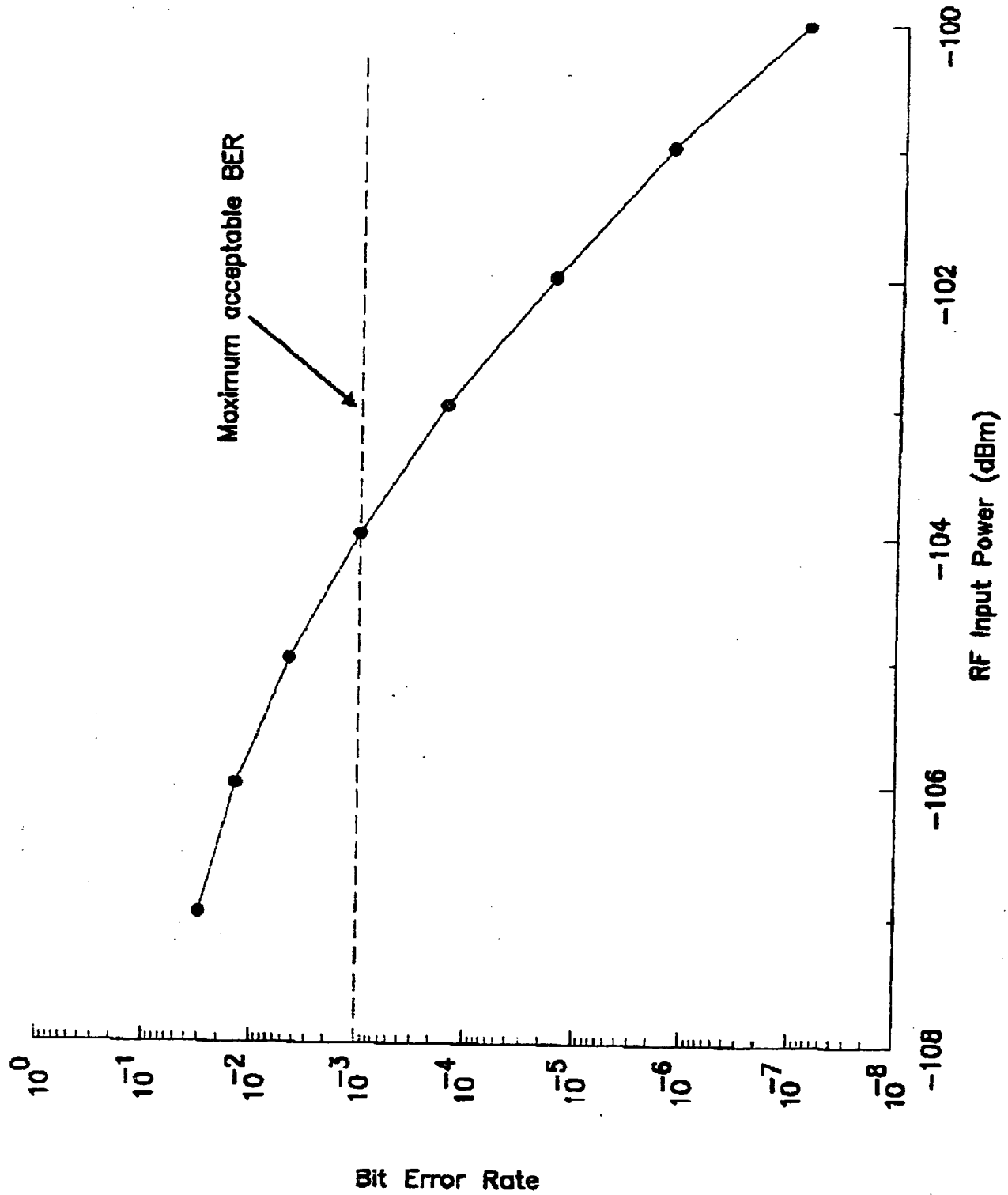


FIG. 4

5/16

FIG. 5

<u>Receiver</u>	
Sensitivity	-104dBm
Dynamic Range	110dB
Noise figure (DSB)	4.5dB
IIP2 (high gain)	+22dBm
IIP3 (high gain)	-21dBm
Selectivity (co-channel, 1.5MHz, 3MHz)	3dB, 23dB, 57dB
Blocking (4.5MHz)	67dB
Power dissipation (3.3V)	525mW
<u>Transmitter</u>	
Output power (into 50Ω)	2, 8, 14, 20dBm
Bandwidth	1.5MHz
Modulation accuracy	±1%
Power dissipation (3.3V, 2dBm)	254mW
<u>General</u>	
Technology	0.6-μm 2P3M CMOS
Die area	5.4mm x 6.7mm

6/16

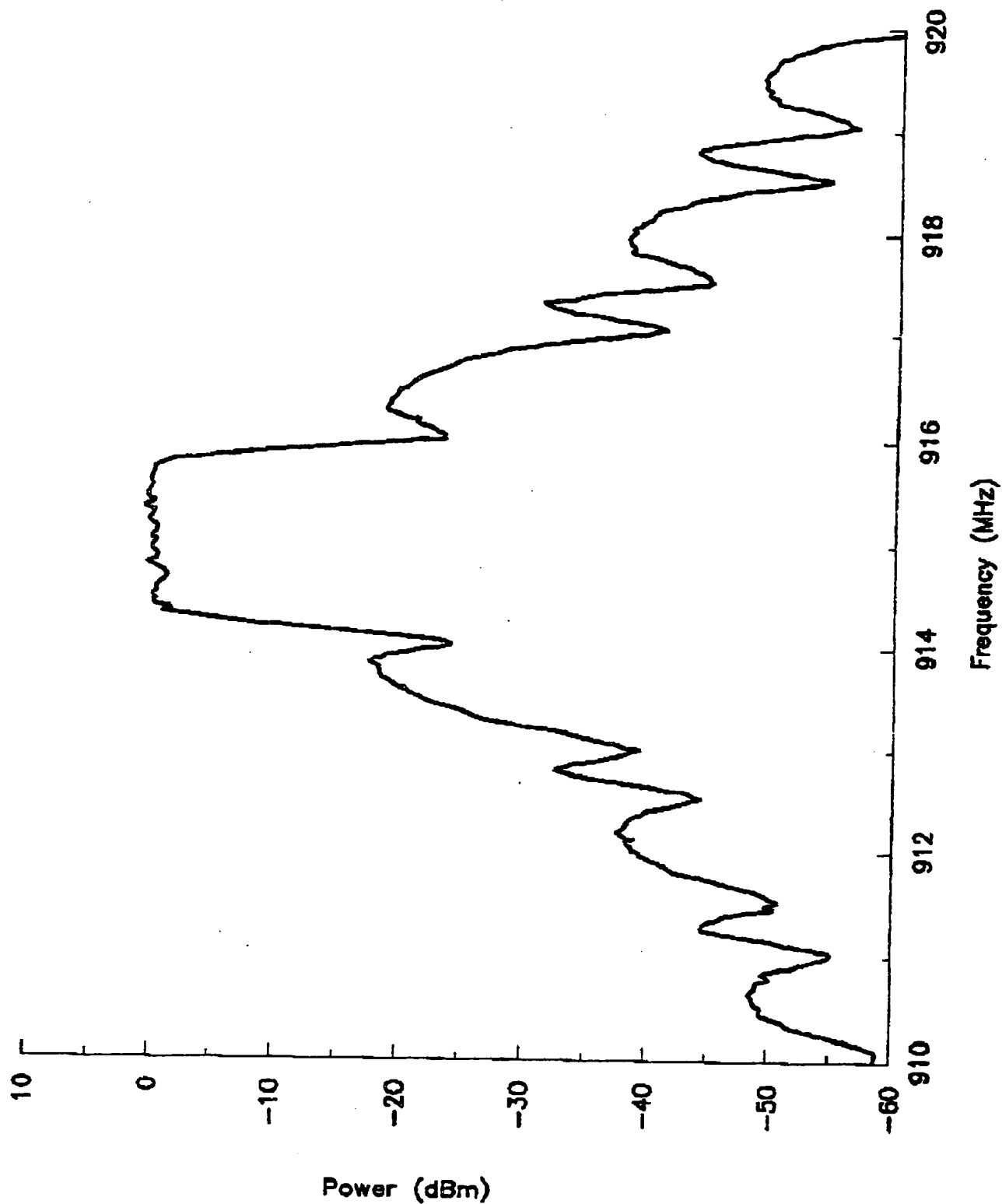
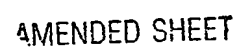


FIG. 6

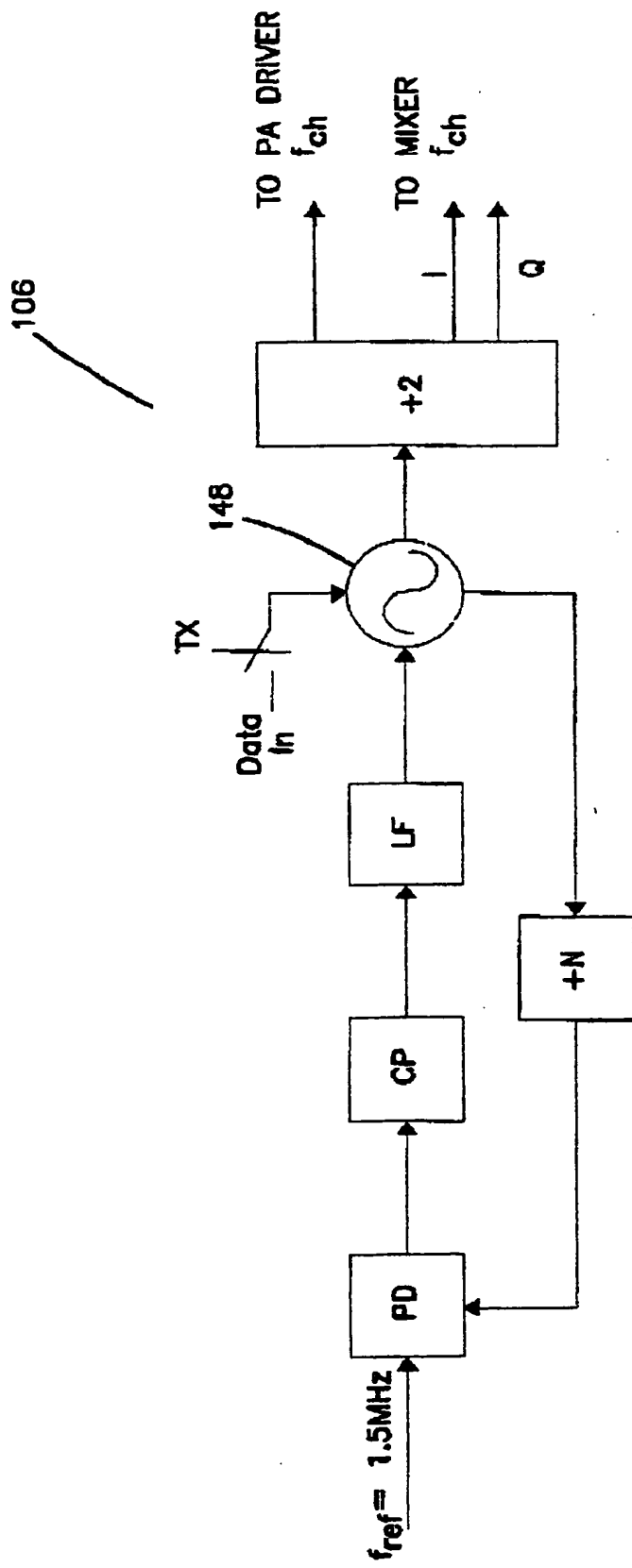
**FIG. 7**





8/16

FIG. 8



9/16

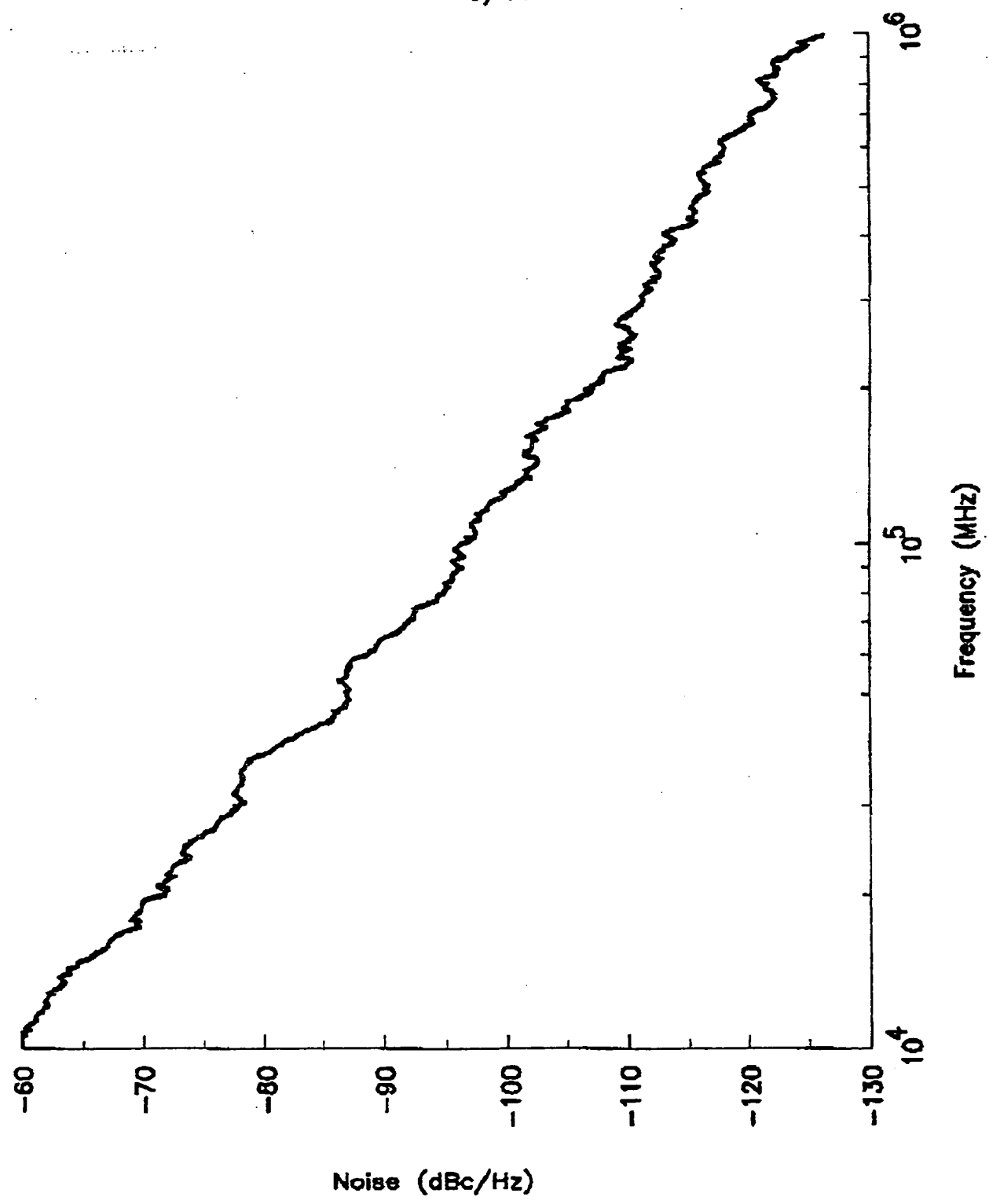


FIG. 9

10/16

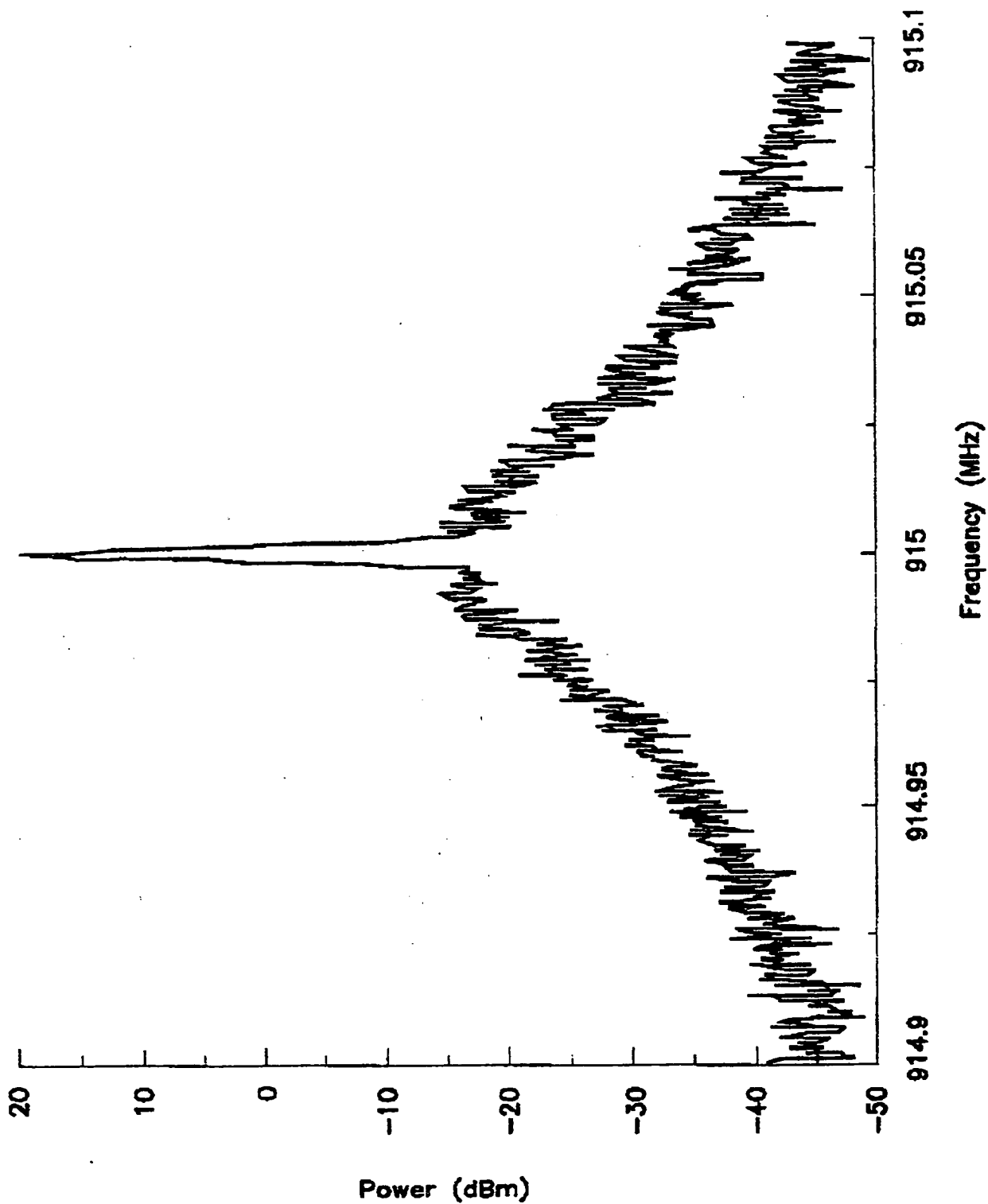


FIG. 10

11/16

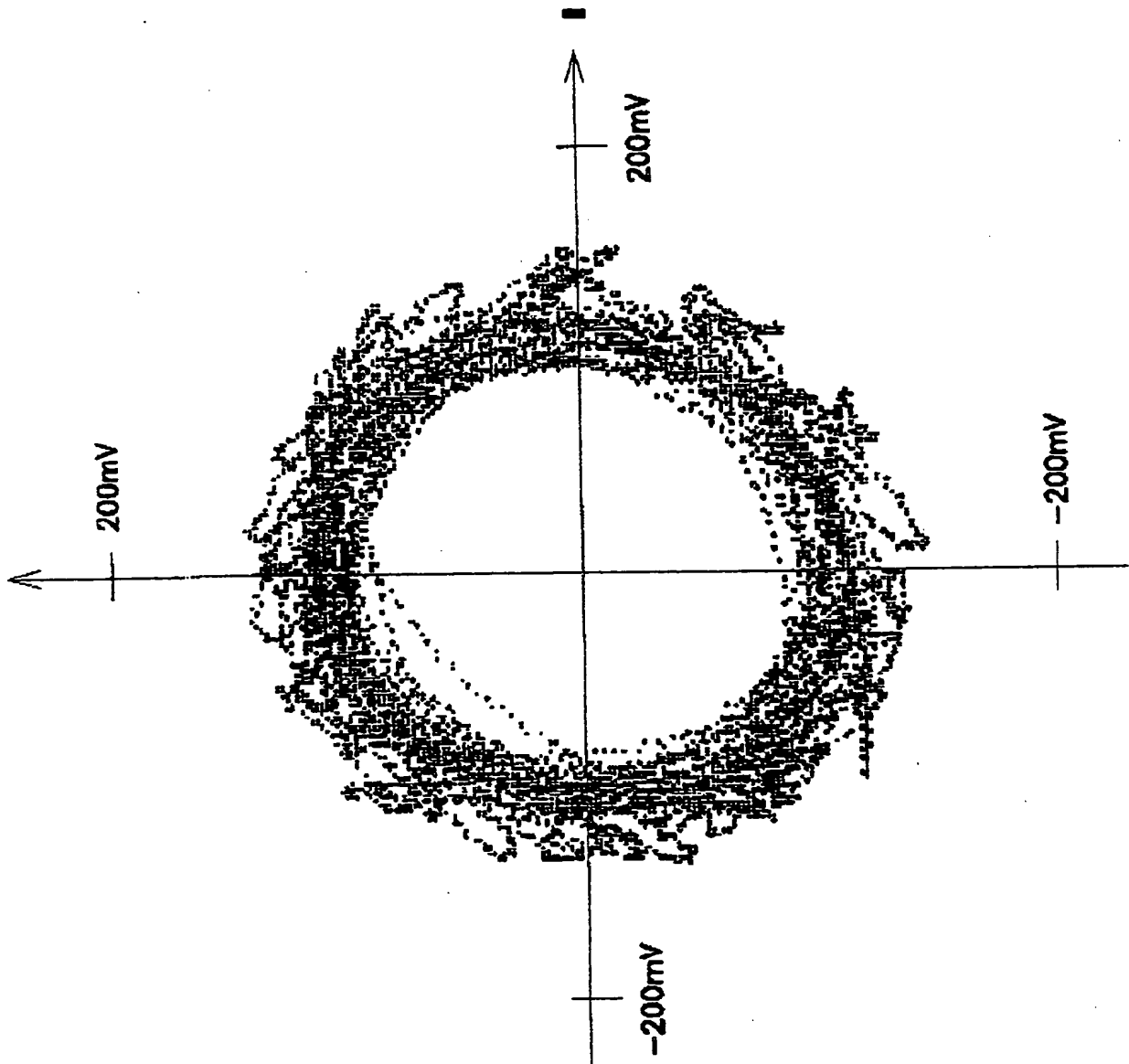
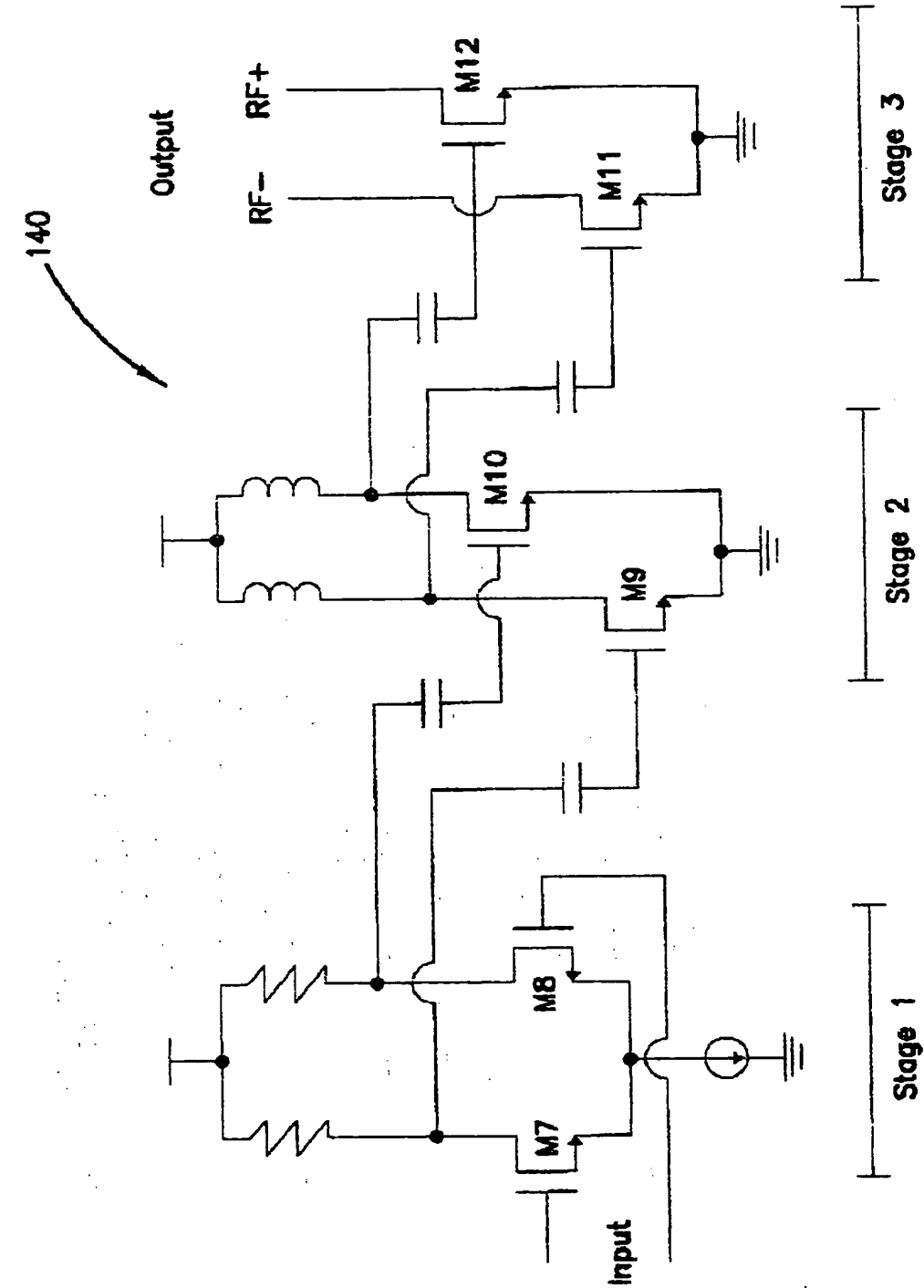


FIG. 11

12/16



13/16

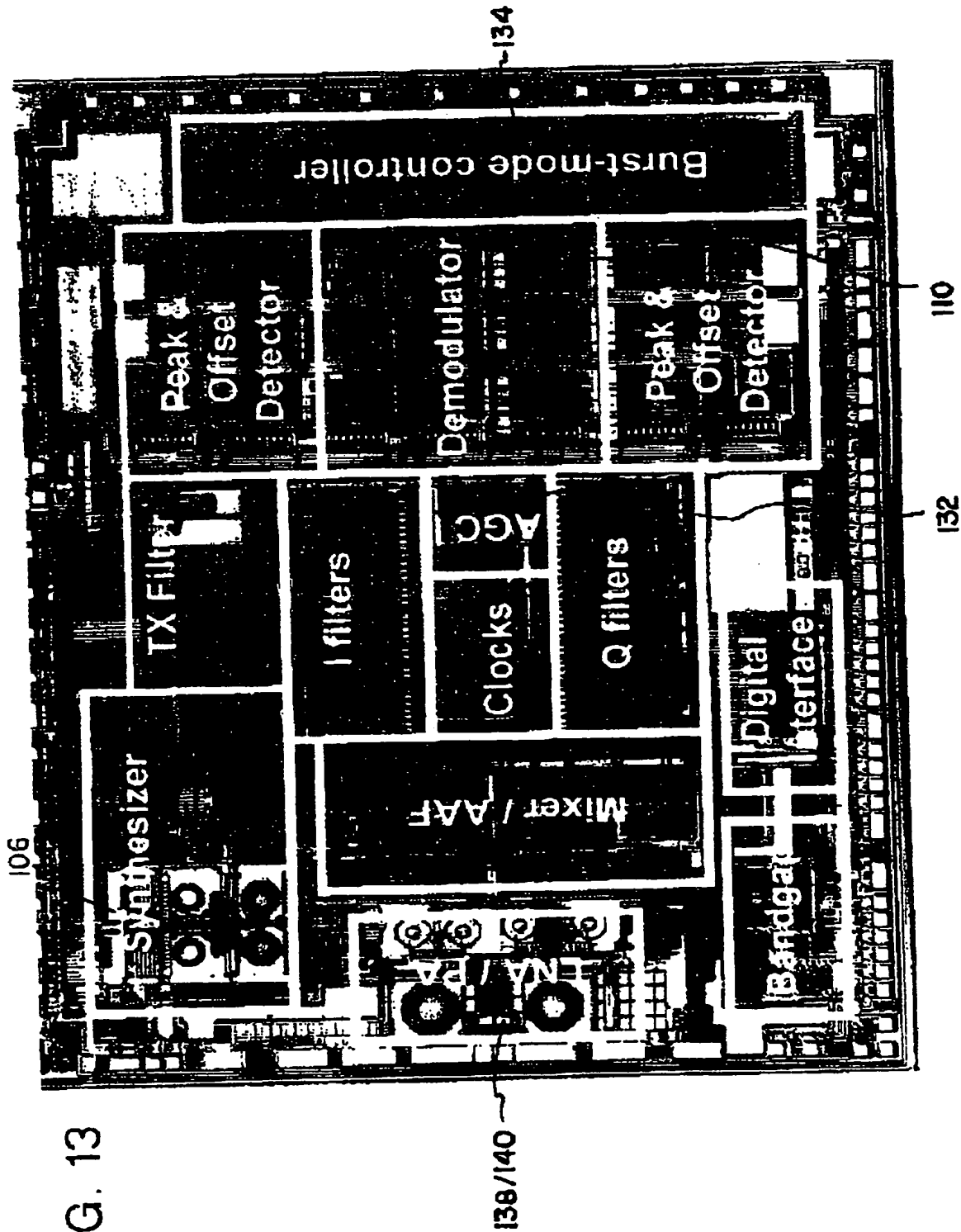


FIG. 13

14/16

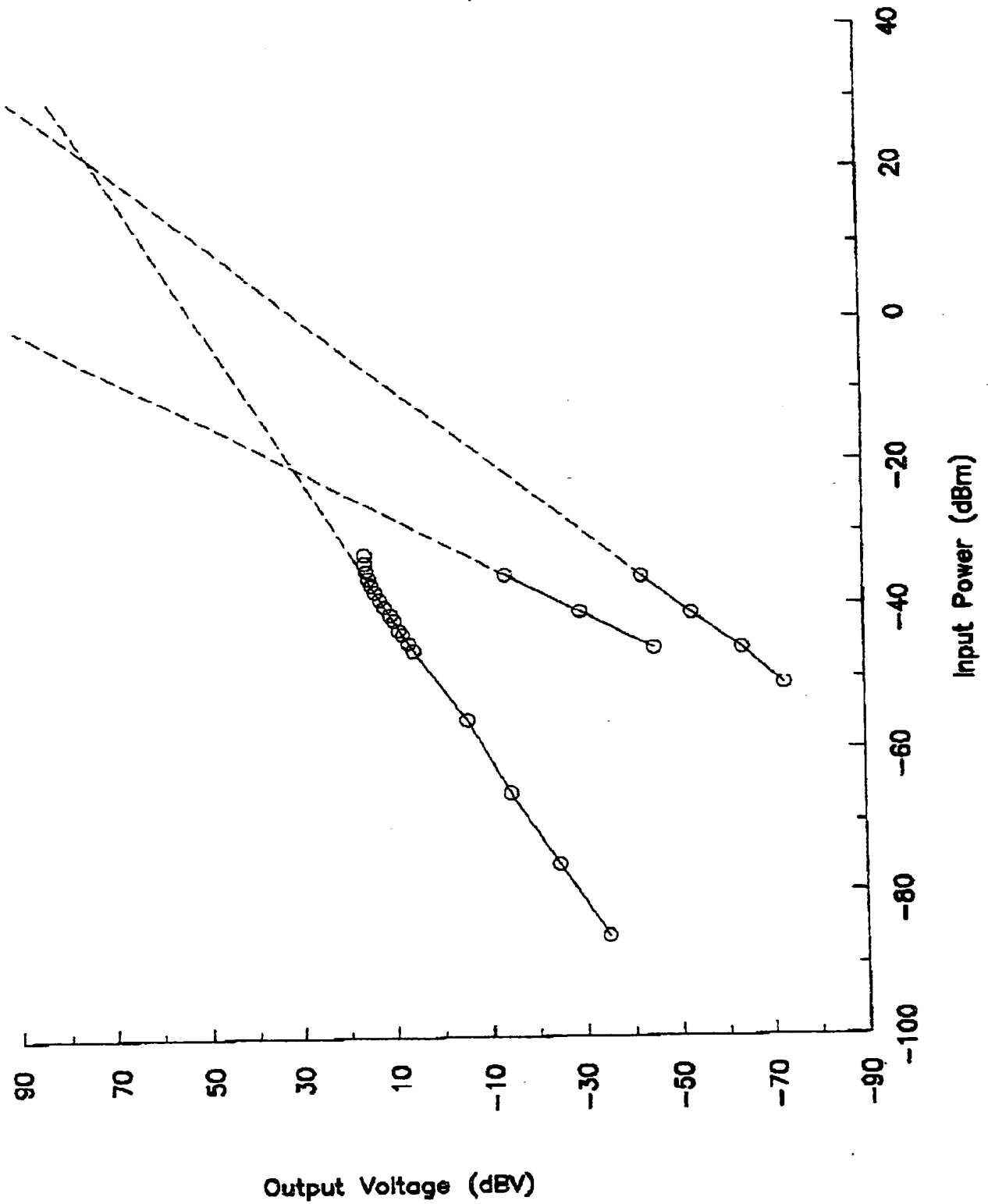


FIG. 14

15/16

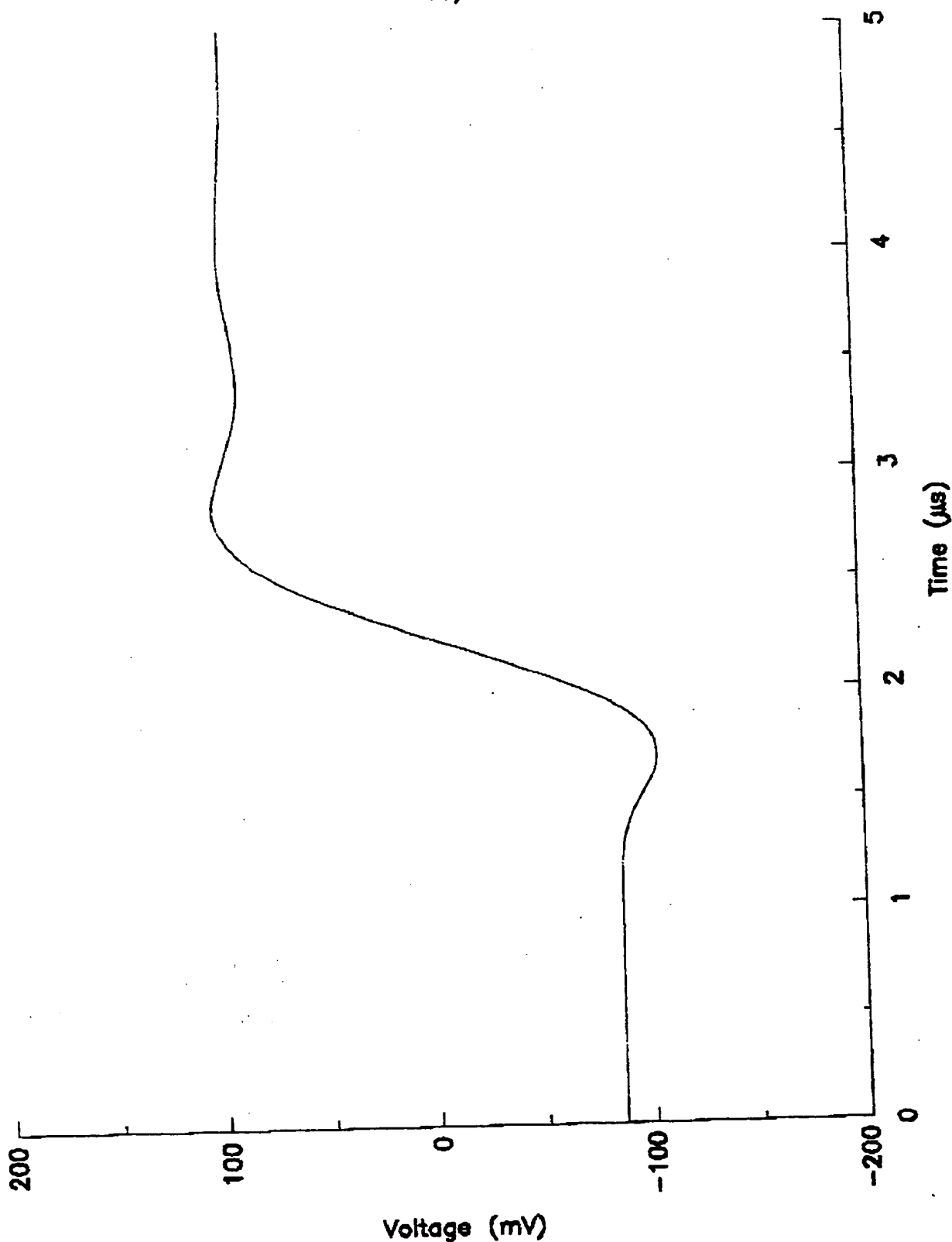
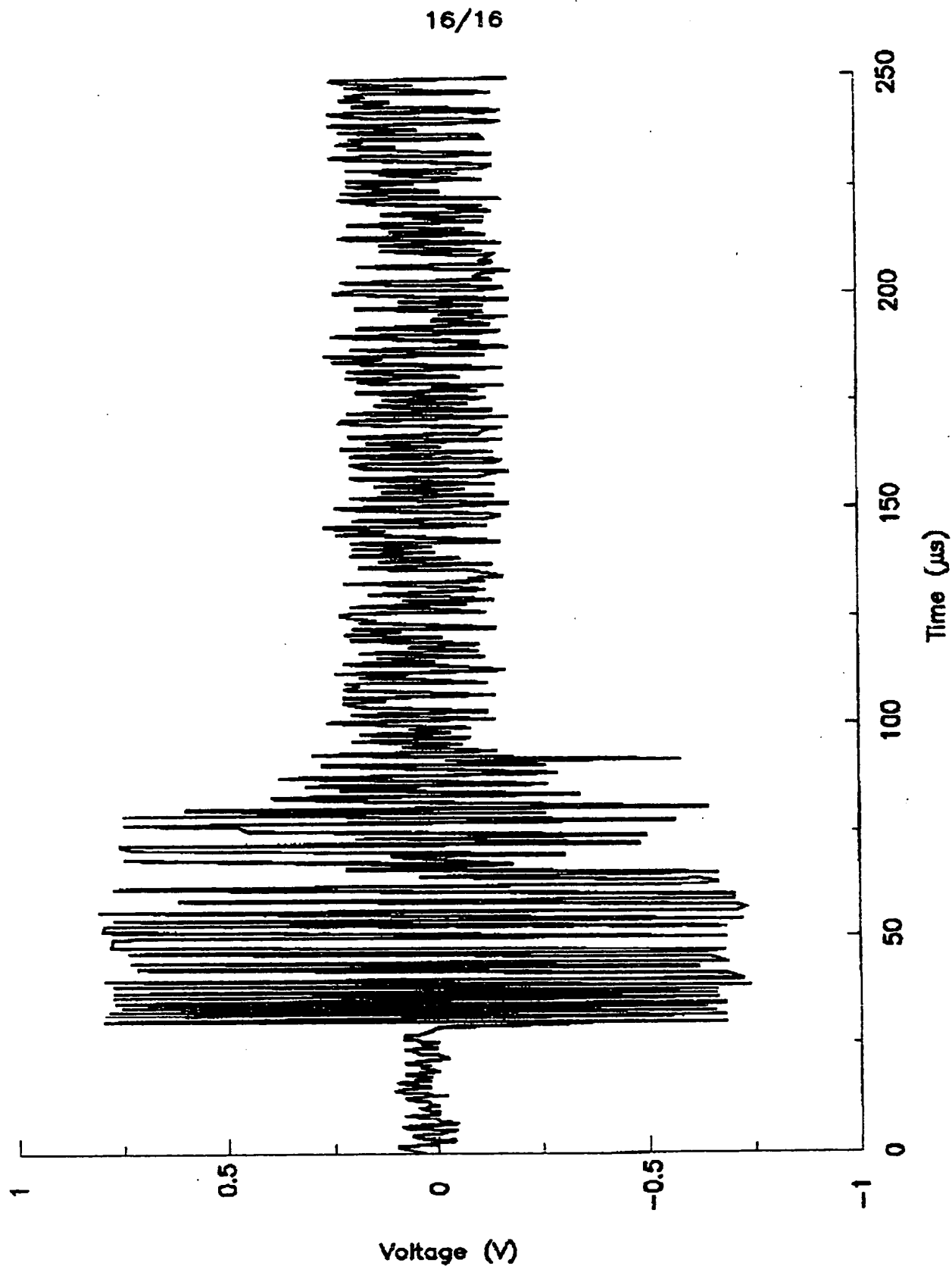


FIG. 15



FIG. 16

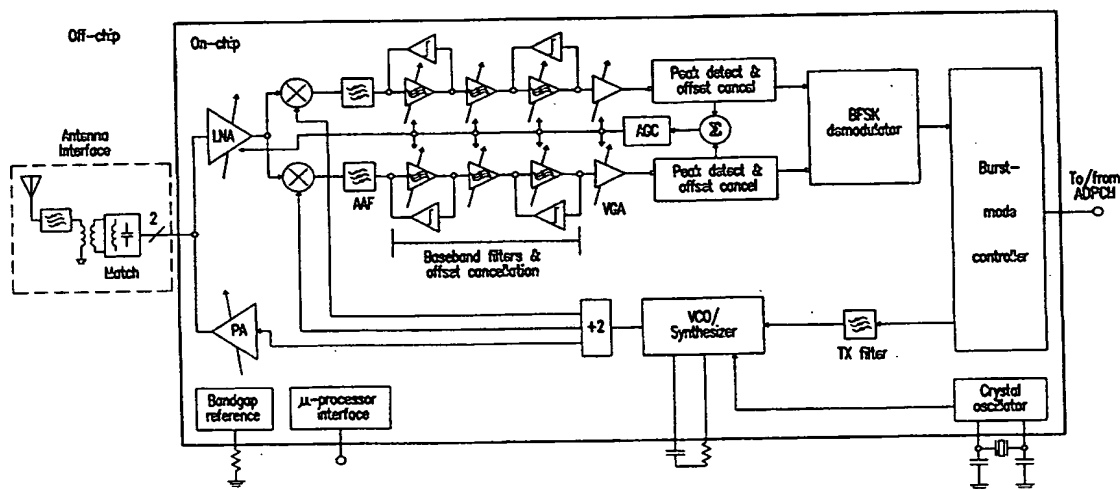




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>H04B 1/30, 1/40</b>	<b>A1</b>	(11) International Publication Number: <b>WO 00/16492</b> (43) International Publication Date: 23 March 2000 (23.03.00)
<p>(21) International Application Number: PCT/US99/20792</p> <p>(22) International Filing Date: 10 September 1999 (10.09.99)</p> <p>(30) Priority Data: 60/099,723 10 September 1998 (10.09.98) US</p> <p>(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application US 60/099,723 (CON) Filed on 10 September 1998 (10.09.98)</p> <p>(71) Applicant (for all designated States except US): LEVEL ONE COMMUNICATIONS, INC. [US/US]; 9750 Goethe Road, Sacramento, CA 95827 (US).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): MACNALLY, Donald, Evan [US/US]; 141 Bronte Street, San Francisco, CA 94110 (US). CHO, Thomas, B. [US/US]; 356 Oleander Avenue, Alameda, CA 94502 (US). RABII, Shahriar [US/US]; 2162 Stauton Court, Palo Alto, CA 94306 (US). MEHTA, Srenik, Suresh [US/US]; 1468 8th Avenue, San Francisco, CA 94122 (US). NILSON, Christopher, Donald [US/US]; 170 South 14th Street, San Jose, CA 95112 (US). MACK,</p>		<p>Michael, Peter [US/US]; 3114 Clay Street #1, San Francisco, CA 94115 (US). PLOUVIER, Laurence, Marguerite [US/US]; 141 Bronte Street, San Francisco, CA 94110 (US). MARRINGA, Menno [NL/US]; 25 Conrad Street, San Francisco, CA 94131 (US). DUKATZ, Eric, S. [US/US]; Apartment 2, 1012 Kirkham Street, San Francisco, CA 94122 (US).</p> <p>(74) Agent: BRUESS, Steven, C.; Merchant &amp; Gould P.C., 3100 Norwest Center, 90 South Seventh Street, Minneapolis, MN 55402-4131 (US).</p> <p>(81) Designated States: US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p><b>Published</b> With international search report.</p>

(54) Title: A SINGLE-CHIP CMOS DIRECT-CONVERSION TRANSCEIVER



## (57) Abstract

A single-chip CMOS direct conversion transceiver includes an RF circuit, a transmitter having a synthesizer, a receiver having a baseband filter, and a demodulator. The synthesizer is coupled to the RF circuit. The baseband filter is coupled to the RF circuit and the synthesizer. The demodulator is coupled to the baseband filter. The RF circuit, the synthesizer, the baseband filter, and the demodulator are arranged and configured in CMOS devices and provide a complete interface between an antenna and a voiceband codec.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

**A SINGLE-CHIP CMOS DIRECT-CONVERSION TRANSCEIVER****BACKGROUND OF THE INVENTION****1. Field of the Invention.**

5 This invention relates in general to communication systems, and more particularly to a single-chip CMOS direct-conversion transceiver.

**2. Description of Related Art.**

Today's wireless communications markets are being driven by a multitude of user benefits. Products such as cellular phones, cordless phones, pagers, and the like  
10 have freed corporate and individual users from their desks and homes and are driving the demand for additional equipment and systems to increase their utility. As a result digital radio personal communications devices will play an increasingly important role in the overall communications infrastructure in the next decade.

Mixed-signal integration and power management have taken on added  
15 importance now that analog and mixed analog-digital ICs have become the fastest-growing segment of the semiconductor industry. Integration strategies for multimedia consoles, cellular telephones and battery-powered portables are being developed, as well as applications for less integrated but highly specialized building blocks that serve multiple markets. These building blocks include data converters,  
20 amplifiers and voltage regulators. Makers of amplifiers and regulators often eschew integration in CMOS, but strive for compact size and reduced costs with microminiature packaging.

One important aspect of digital radio personal communications devices is the integration of the RF sections of transceivers. Compared to other types of integrated

circuits, the level of integration in the RF sections of transceivers is still relatively low. Considerations of power dissipation, form factor, and cost dictate that the RF/IF portions of these devices evolve to higher levels of integration than is true at present. Nevertheless, there are some key barriers to realizing these higher levels of  
5 integration.

A high level of integration is critical in lowering the cost of electronics for communication systems such as cellular phones, cordless phones, and wireless LANs. Increasing levels of transceiver integration are being reported, e.g., RF, baseband analog, and mixed-signal circuits have been integrated. Further, RF,  
10 baseband analog, and voltage-controlled oscillator (VCO) circuits have also been realized in a single die.

It can be seen that there is a need for a fully-integrated transceiver.

It also can be seen that there is a need for a fully-integrated transceiver that incorporates RF circuits, synthesizer, baseband filters, demodulator, and extensive  
15 digital control functions.

### SUMMARY OF THE INVENTION

To overcome the limitations in the prior art described above, and to overcome other limitations that will become apparent upon reading and understanding the present specification, the present invention discloses a single-chip  
20 CMOS direct-conversion transceiver.

In one embodiment of the present invention, the single-chip CMOS direct-conversion transceiver includes an RF circuit, a transmitter having a synthesizer, a receiver having a baseband filter, and a demodulator. The synthesizer is coupled to the RF circuit. The baseband filter is coupled to the RF circuit and the synthesizer.  
25 The demodulator is coupled to the baseband filter. The RF circuit, the synthesizer,

the baseband filter, and the demodulator are arranged and configured in CMOS devices and provide a complete interface between an antenna and a voiceband codec.

Another aspect of the invention is that the transceiver further includes a time-division duplex (TDD) circuit for ensuring isolating between the transmitter  
5 and the receiver.

A further aspect of the invention is that the transmitter and the receiver share the same RF port which interfaces with an external antenna.

### BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in which like reference numbers represent  
10 corresponding parts throughout:

Fig. 1 illustrates a block diagram of the single-chip CMOS transceiver according to the present invention;

Fig. 2 illustrates the low noise amplifier according to the present invention;

Fig. 3 is a circuit diagram of the mixer and antialias filter according to the  
15 present invention;

Fig. 4 illustrates a plot of the receiver bit error rate (BER);

Fig. 5 is a table illustrating the performance characteristics of the single-chip CMOS transceiver;

Fig. 6 illustrates the transmit spectrum for 20 dBm output power;

20 Fig. 7 illustrates the voltage controlled oscillator;

Fig. 8 illustrates a block diagram of the synthesizer;

Fig. 9 is a phase noise plot for the single-chip CMOS transceiver;

Fig. 10 is a plot of the unmodulated output spectrum for the single-chip CMOS transceiver;

25 Fig. 11 illustrates the measured I/Q constellation for a -80dBm RF input;

Fig. 12 illustrates a circuit diagram for the power amplifier;

Fig. 13 illustrates the die micrograph of the single-chip CMOS transceiver;

Fig. 14 is the intermodulation (IM) plot for the entire receive path;

Fig. 15 shows the measured step response of the channel filters; and

Fig. 16 shows a change in the output levels of the channel filters in response

5 to a change in the amplitude of a receive burst.

### DETAILED DESCRIPTION OF THE INVENTION

In the following description of the exemplary embodiment, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration the specific embodiment in which the invention may be practiced.

10 It is to be understood that other embodiments may be utilized as structural changes may be made without departing from the scope of the present invention.

In an embodiment of the present invention is a specific combination of building blocks that realize a monolithic transceiver for digital communication that may be used for various media.

15 A function of the monolithic transceiver is to convert digital data to an analog signal suitable for transmission and to convert a received analog signal into digital data. In practice, there will be a finite bit error rate in the transmission, propagation and reception processes. The specific BER that is tolerable depends on the application. In some cases, the input to one monolithic transceiver and at the  
20 output of another monolithic transceiver may be different because of intentional signal processing.

Typically, a pair of monolithic transceivers is used for full duplex communication. However, more than two monolithic transceivers can be used in more complex communication systems. In some cases, the communication is only  
25 required from one point to another without full duplex. In some cases, different media may be used for each direction of a full duplex system. In some cases, the

monolithic transceiver may include multiple receivers and transmitters. In some cases, the analog signal may be converted from one media to another along propagation. Each receiver and transmitter in the monolithic transceiver may be intended for different media.

- 5           The digital data communicated may originate from an arbitrary source and will be delivered to an arbitrary target. Common sources and targets include: (1) Computers, (2) Sensors, (3) Magnetic or optical media, (4) Other monolithic transceivers.

          The analog signal is typically propagated using one or more of the following  
10   methods: (5) Free space radiation, (6) Transmission lines: (a) Coaxial cables, (b) Twisted pairs, (c) Waveguides, (7) Fiber optics, (8) Sonar in liquid, solid or gas media.

          The elements used in the monolithic transceiver include the following means:  
(9) Digital processing and control circuits, (10) Analog-to-Digital, Analog, Digital-  
15   to-Analog processing circuits, (11) Media interface processing circuits.

          The digital processing circuits are used to condition data from a source into internal digital data in the monolithic transceiver destined for transmission and to condition received internal digital data in the monolithic transceiver for a target. The digital control circuits are used to coordinate the activities of the monolithic  
20   transceiver necessary to accomplish half-duplex, full-duplex or more complex communication systems and to coordinate digital communication with the source and target.

          The analog-to-digital, analog and digital-to-analog processing provides the interface between the digital and analog domains. These functions are commonly  
25   accomplished using analog circuits such as analog-to-digital converters (ADCs), digital-to-analog converters (DACs), filters and automatic gain control systems. In



some cases, these functions may be part of or inherent to other analog functions such as a demodulator.

The media interface processing circuits provide the interface between the analog domain used for transmission and the analog domain used in the monolithic transceiver. In a RF monolithic transceiver, these interface circuits include a low noise amplifier (LNA), power amplifier (PA), mixer and synthesizer. Each type of media has its own specific interface circuit appropriate for that media.

More specifically, the monolithic transceiver design includes the following choices: (12) Time division duplex (TD) or frequency division duplex (FDD), (13) Modulation technique, (14) Narrow-band or wide-band communication, (15) Direct-sequence or frequency hopping spreading and despreading, (16) Silicon or heterojunction semiconductor platforms, (17) MOS or bipolar devices.

The specific attributes chosen may ease implementation of the monolithic transceiver that may make the monolithic transceiver particularly attractive for certain markets.

More specifically, the use of silicon MOS technologies permits the monolithic transceiver to take an advantage of attributes of MOS devices in general and to take an advantage of attributes of short-channel MOS devices in modern CMOS technologies for particular wireless applications.

The use of MOS devices permits the digital processing and control circuits to be accomplished with high density and lower power. This is important because of well-known attributes of MOS devices for logic implementation. This permits implementation of sophisticated digital signal processing for portable wireless applications, as an example.

The use of MOS devices permits analog, A/D, D/A processing circuits to be accomplished using switched-capacitor techniques. This is important because, in

general, MOS devices have the attribute of an extremely large on-state to off-state conductance ratio necessary for an excellent switch. This switch is the basis for sampled-charge based approaches. The use of MOS devices permit a rich and sophisticated array of sampled-data systems to be implemented including ADCs, DACs and filters.

The use of MOS devices permits media interface processing circuits to be accomplished using amplifiers, mixers, and frequency synthesizers. In particular, recent advances in short-channel MOS devices permit the media interface processing circuits to be accomplished at microwave frequencies used in many wireless applications.

More specifically, the use of Bipolar or BiCMOS technology may be used to implement the monolithic transceiver.

The use of BiCMOS technology can be used to accomplish a monolithic transceiver with the digital processing and control circuits using CMOS devices, the analog, A/D, D/A circuits and the media interface processing circuits using a combination of bipolar or CMOS devices.

The use of bipolar technology can be used to accomplish the monolithic transceiver. This approach may be better for specialized applications such as millimeter wave systems where HBT devices are more appropriate. Other applications where bipolar devices may be a better choice include fiber-optic applications.

The use of bipolar devices does not permit the digital processing and control circuits to be accomplished with high density or low power. However, high speed may be the advantage.

The use of bipolar devices does not permit the analog, A/D, D/A circuits to use switched-capacitor techniques. This is a major limitation because of

sophistication possible with switched-capacitor sampled-data systems. The bipolar device can be used to implement sampled-data systems using other techniques such as switched-current approaches. However, sampled-data systems built with these approaches are far less flexible and use far more power than switched-capacitor techniques.

The use of bipolar devices does permit the media interface processing circuits to be accomplished with more ease at present. However, future advances in CMOS process technology may favor CMOS devices for the media interface processing circuits.

More specifically, the choice of modulation technique influences the complexity of certain blocks. For example, the use of FSK modulation relaxes the linearity requirement of the PA. This is important as at present, CMOS PAs are not easily accomplished with high linearity.

The following description discusses one embodiment of a monolithic transceiver implementation that uses CMOS technology, FSK modulation, switched-capacitor techniques for sampled-data systems and a relatively complex digital signal processor and control unit.

In one embodiment, the present invention provides a single-chip CMOS direct-conversion transceiver. As stated above, a high level of integration is critical in lowering the cost of electronics for communication systems such as cellular phones, cordless phones, and wireless LANs. The present invention provides a fully-integrated transceiver 100, shown in Fig. 1, that incorporates RF circuits 102, 104, synthesizer 106, baseband filters 108, demodulator 110, and digital signal processing. The few off-chip components include an ISM band filter 112, a balun 114, an RF matching network 116, an RC loop filter for the PLL 118, a crystal resonator 120, and a resistor 122 for biasing. The use of a transmit/receive (T/R)

switch is avoided by sharing a single RF port between a transmitter 124 and a receiver 126. An offset cancellation method attenuates offsets in the baseband without sacrificing bandwidth in the direct conversion receiver 126. Careful circuit, timing, and layout considerations provide isolation between the sensitive RF signal and the digital switching noise. The IC has been fabricated in 0.6- $\mu$ m CMOS and provides a complete interface between an antenna 128 and a voiceband codec 130.

Architectural and circuit techniques have made it possible to achieve this level of integration without sacrificing performance. Time-division duplex (TDD) ensures isolation between the transmitter 124 and the receiver 126. Direct conversion makes it possible to eliminate expensive, off-chip radio frequency (RF) image reject filters and diplexer, and to replace off-chip intermediate frequency (IF) channel select filters with on-chip low pass filters.

Active on-chip offset reduction by means of feedback and feedforward loops has been combined with a digitally controlled automatic gain control (AGC) circuit 132 that settles within the 160- $\mu$ s preamble of the receive burst.

In a direct conversion receiver 126, static and varying DC offsets within the base band I and Q channel amplifiers and filters limit the architecture's usefulness. In the past, AC coupling or high pass filtering has been used to remove the DC offset from the signal. However, this removes some of the useful DC or near DC energy from the signal causing degradation to the signal. The present invention uses a combined feedback and feedforward offset cancellation technique with DC signal response to cancel the DC offset problem while at the same time providing for a DC response to the base band signals of interest.

The main feature of the feed forward offset cancellation architecture is its capability to cancel low frequency (DC to 5 kHz) offsets caused by LO leakage and other non-ideal component induced offsets while at the same time maintaining a DC

response to the signal. This is accomplished by two main components of the architecture.

The first main component is the signal format. A signal format was chosen such that the I and Q base band signals exhibit a positive and negative peak within a certain time frame, 6.66 micro-seconds was chosen. The peaks and valleys of the I and Q signals from one time frame to the next are required to be approximately equal.

The second main component is a positive and negative peak detector which determines the peaks and valleys of the signal over a certain time frame (6.66uS). The offset is then the addition of the positive and negative peaks divided by two.

A fully-differential analog signal path minimizes supply and substrate noise coupling. To further reduce coupling, transitions of digital signals have been minimized near the sampling edge of baseband switched-capacitor circuits. Source-coupled logic has been utilized in the PLL frequency dividers to reduce substrate noise injection, while CMOS logic gates have been used in a burst-mode controller (BMC) 134 to achieve low power dissipation and high circuit density. An automatic calibration technique has allowed the integration of a 1.8-GHz LC VCO with a wide tuning range. The receiver 126 has a maximum gain of 106 dB and a sensitivity of -104 dBm.

A low noise amplifier (LNA) 138 and the power amplifier (PA) 104 designs make it possible to share a common RF port 140, thereby eliminating the need for an external transmitter/receiver switch. The transmitter 124 and receiver 126 are attached to the filter/antenna port of a radio transceiver without the need for a costly antenna switch in a time division duplex system.

Radio transceivers usually require both a Low Noise Amplifier or (LNA) for clear reception and a Power Amplifier or (PA) for transmitting over long distances.

In a time division duplex or (TDD) transceiver 100, the transmitter 124 and receiver 126 are not utilized simultaneously. When the transmitter 124 is on, the receiver 126 is off, and when the receiver 126 is on, the transmitter 124 is off. For a typical TDD transceiver 100, the receive LNA 138 is powered down during the transmit cycle to conserve power, and the transmit power amplifier 140 is powered down while the receiver 126 is on.

In the past, the LNAs and PAs have been designed utilizing bipolar transistor technology. The bipolar LNAs and PA's are capable of powering down, however their respective input and output impedance while in the powered down state do not allow them to be connected together in a TDD system. The powered down LNA will attenuate the output power of the PA and may even be damaged by the PA. The powered down PA will lower the impedance that the LNA "sees" and will attenuate the incoming signal from the antenna.

To get around the varying impedance problem, LNA and PA typically use their own set of different matching components to produce a 50 Ohm LNA input impedance and 50 Ohm PA output impedance. This topology is then combined with an antenna switch so that the off state impedances of either the LNA or the PA will not harm the 50 match achieved by the different matching components. However, the antenna switch can be costly, and the transmit and receive signals are still attenuated somewhat by the switch itself. In addition a control circuit must be used to switch the antenna switch.

According to the present invention, the antenna interface requires only one RF combined input/output port thereby reducing IC package pin count and the number of external components. An impedance transformation network of 25 to 50 ohm network is used to ease the LNA requirement. A singly matched network is used for PA since putting required matching 50 ohm will limit the theoretical power

efficiency to less than 50% and will degrade the power efficiency achieved in practice.

The LNA 138, shown in Fig. 2, is implemented as a cascade of two stages. The first stage employs a capacitively cross-coupled input pair, M1 and M2, that provides both gain and impedance matching in parallel with a differential pair, M3 and M4, for additional gain. The second stage of the LNA 138 is also a differential pair. All gain stages are loaded by on-chip spiral inductors. The combined LNA gain can be set to 12 dB or 28 dB.

The PA 140 is implemented as a three-stage, class AB amplifier. The first stage is a resistively loaded differential pair, the second stage is a common-source stage loaded with on-chip spiral inductors, and the output stage consists of large open drain devices whose drains are connected to the LNA input. The bias currents of the final stage are provided by off-chip RF chokes. The output power, measured at the balun, can be varied from +2 dBm to +20 dBm. Refer to Fig. 12.

A diagram of a mixer 142 and antialias filter 144 is shown in Fig. 3. The mixer's conversion gain is 14.3 dB. The mixer uses a double balanced structure without a tail current source to increase headroom. Biasing for the RF input transistors is performed by a replica circuit that suppresses transconductance variations with process and temperature. The LO input transistors operate as switches that steer a process and temperature independent current. The output of the mixer 142 is fed to a four-pole Butterworth antialias filter 144 with a cut-off frequency of 2.4 MHz.

Two biquad stages form the four-pole Butterworth antialias filter 144 with a nominal gain of 15.6 dB and a cut-off frequency of 2.4 MHz. Switched-capacitor and Q baseband filters sample the output of the antialias filter 144 at 24 MHz, attenuate adjacent channels, and provide AGC 132. Each baseband signal path

comprises a fourth-order low pass Chebyshev filter, implemented with two biquad sections, followed by a group delay equalizer (GDE). The biquads and the GDE have a programmable gain of one or four. The filter is followed by a switched-capacitor variable gain amplifier (VGA) that is programmable with a gain of one, two, or four. This arrangement provides a baseband gain of 0 dB to 48 dB in 6 dB steps.

In a direct conversion receiver 126, LO leakage can lead to large offsets at the inputs to the baseband filters 108. Moreover, offsets in the switched-capacitor filter sections can accumulate and render the output signal undetectable. To overcome this problem, feedback integrators cancel offsets in the first biquad and in the GDE, as shown in Fig. 1. To prevent baseline wander from causing errors, the integrators are placed in a hold mode when data is transferred.

Switched-capacitor peak detector circuits 146 sample the maximum and minimum values of the filtered I and Q signals. The AGC controller 132 uses the peak detector 146 outputs to estimate the signal levels and adjusts the baseband gain accordingly. The outputs of the peak detectors 146 are also low pass filtered to estimate the residual offset in the outputs of the channel filters. The offset is then subtracted from the baseband filter output, and the resulting I and Q signals are fed to the BFSK demodulator 110.

The BFSK demodulator 110 is implemented with switched-capacitor circuits clocked at 6 MHz. It generates a digital output based on the direction of rotation of the I/Q constellation. The digital output of the demodulator 110 is processed by the on-chip BMC 134, comprising over 8000 CMOS standard cell gates, that performs clock recovery and direct sequence spreading and despreading. The receiver bit error rate (BER), shown in Fig. 4, illustrates the receiver sensitivity. Selectivity and blocking performance are given in the table in Fig. 5.



The single frequency synthesizer 106 creates both LO and PA input signals for receive and transmit, respectively. The circuit generates channels from 900 MHz to 930 MHz in 750kHz increments. During receiving, a divide-by-two circuit creates I and Q LO signals from the output of a VCO operating at twice the desired frequency in a high bandwidth PLL. During transmit, the PLL bandwidth is reduced allowing filtered transmit data to directly modulate the VCO while maintaining a constant center frequency. The transmit spectrum for 20 dBm output power is shown in Fig. 6. The VCO, shown in Fig. 7, is designed as a cross-coupled differential pair loaded by spiral inductors and by capacitors. The load capacitors include ac-coupled channel varactors, modulation varactors, and a bank of capacitors for automatic coarse frequency adjustment.

The synthesizer 106 architecture is shown in Fig. 8. The varactors are on chip. The VCO 148 operates at twice the carrier frequency in order to alleviate problems arising from PA pulling. Furthermore, it allows the robust creation of I and Q signals using a simple divide-by-two circuit. A phase noise plot is provided in Fig. 9, and the output spectrum is shown in Fig. 10.

The VCO 148 is automatically calibrated in a closed loop with control circuitry that digitally adjusts the capacitive load of the tank. The measured I/Q constellation for a -80dBm RF input is shown in Fig. 11. The PA circuit 140 is illustrated in Fig. 12. The power efficiency of the PA 140 is 20% at +20 dBm.

The measured performance, summarized in the table of Fig. 5, demonstrates that a single-chip CMOS transceiver 100 can successfully integrate the RF front end along with baseband analog circuits and a significant amount of standard cell digital circuits. Fig. 13 illustrates the die micrograph of the single-chip CMOS transceiver 100.

The intermodulation (IM) plot for the entire receive path is shown in Fig. 14.

This plot was generated by applying two tones that are 6 channels away from the carrier and recording the power of the IM product at the output of the baseband filters. The tones were chosen such that the IM products are well within the

5 bandwidth of the baseband filters 108. The measurements include the influence of on-chip test buffers on the receiver linearity. The input signal power was measured at the input to the chip, and the LNA gain was in its "high" settings. The 1-dB compression point is limited by the switched-capacitor circuits and occurs at approximately 5V differential amplitude.

10 All switched-capacitor stages in the baseband filters 108, peak detectors 146, and demodulator 110 employ correlated double sampling (CDS) to attenuate their offsets and  $1/f$  noise. To minimize offsets due to mismatch in sampling switches, NMOS rather than CMOS switches have been used. The four clock signals include two-phase, non-overlapping and delayed phases that are driven by voltage doublers.

15 Static charge pumps drive the gain selection switches in the baseband filters 108 and VGA. Fig. 15 shows the measured step response of the channel filters. Fig. 16 shows a change in the output levels of the channel filters in response to a change in the amplitude of a receive burst.

The selectivity, as shown in the table of Fig. 5, was measured by applying a –

20 83 dBm desired signal, then increasing the power of an interferer until the BER reached  $10^{-3}$ . The difference between the power of the interferer and –83 dBm is the selectivity. This test was performed with the interferer within the desired channel as well as 1.5 MHz, 3 MHz, and 4.5 MHz from the carrier. When the interfering tone is 4.5 MHz from the carrier, the receiver's BER is limited by the linearity of the front

25 end. Hence, this measurement represents the blocking performance of the receiver

126.

The foregoing description of the exemplary embodiment of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching.

What is claimed is:

1. A single-chip direct conversion transceiver, comprising:  
an RF circuit;  
a transmitter having a synthesizer;  
5 a receiver having a baseband filter and a demodulator; and  
wherein the synthesizer is coupled to the RF circuit, the baseband filter is coupled to the RF circuit, and the demodulator is coupled to the baseband filter.
- 10 2. The transceiver of claim 1, further comprising a time-division duplex (TDD) circuit for ensuring isolating between the transmitter and the receiver.
3. The transceiver of claim 1, wherein the transmitter and the receiver share the same RF port which interfaces with an external antenna.
- 15 4. The transceiver of claim 1, wherein the synthesizer performs FSK modulation.
5. A single-chip direct conversion receiver, comprising:  
20 an RF circuit;  
a baseband filter and a demodulator; and  
wherein the baseband filter is coupled to the RF circuit, and the demodulator is coupled to the baseband filter.
- 25 6. The receiver of claim 5, wherein the demodulator performs FSK modulation.

FIG. 1

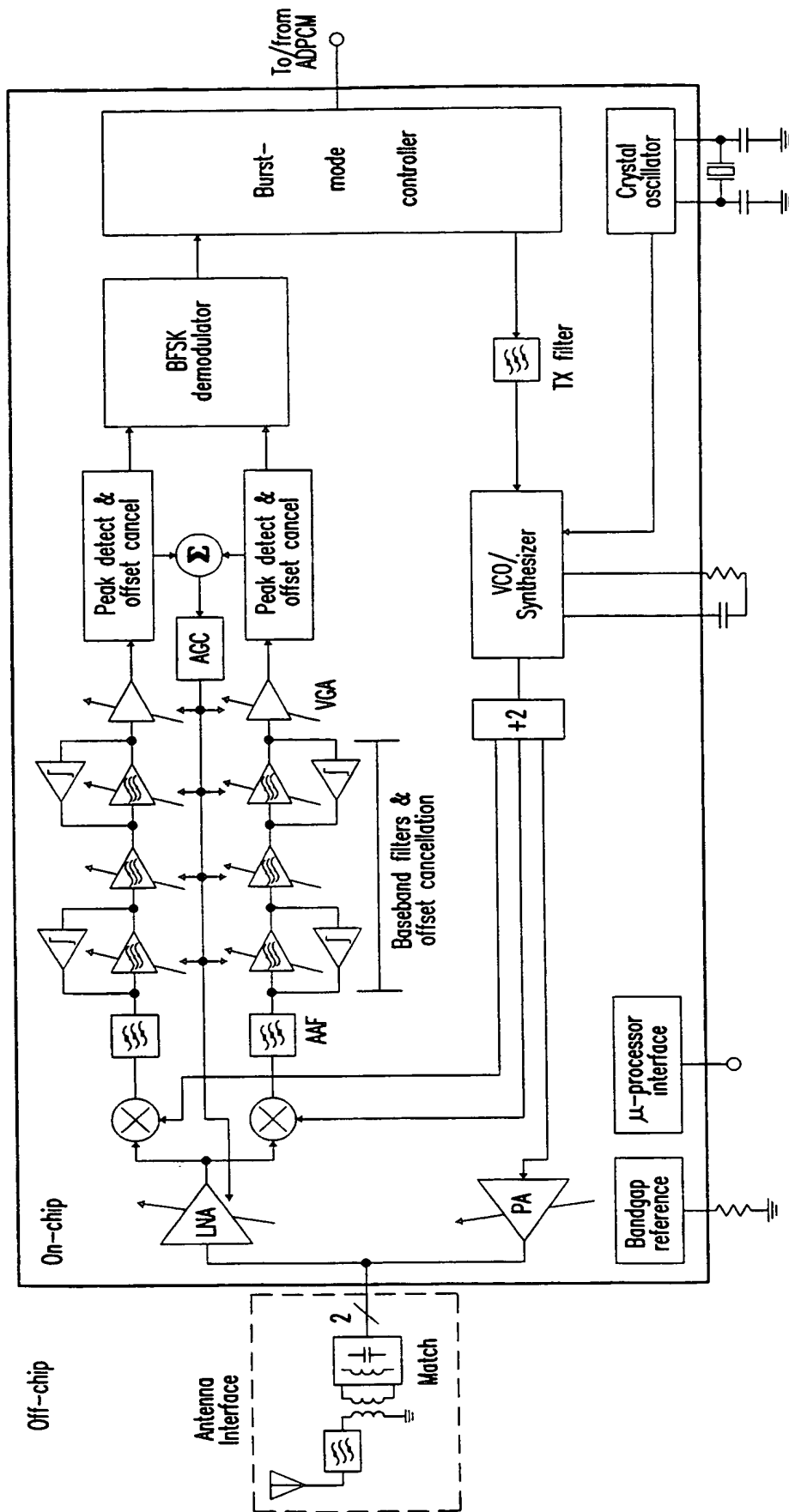


FIG. 2

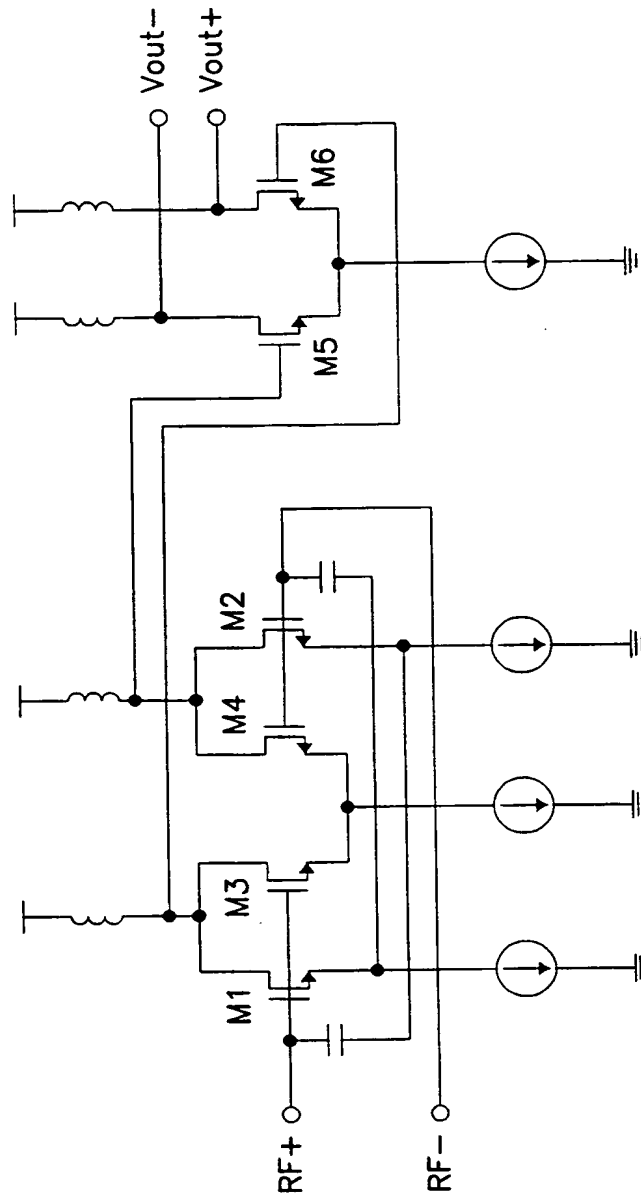
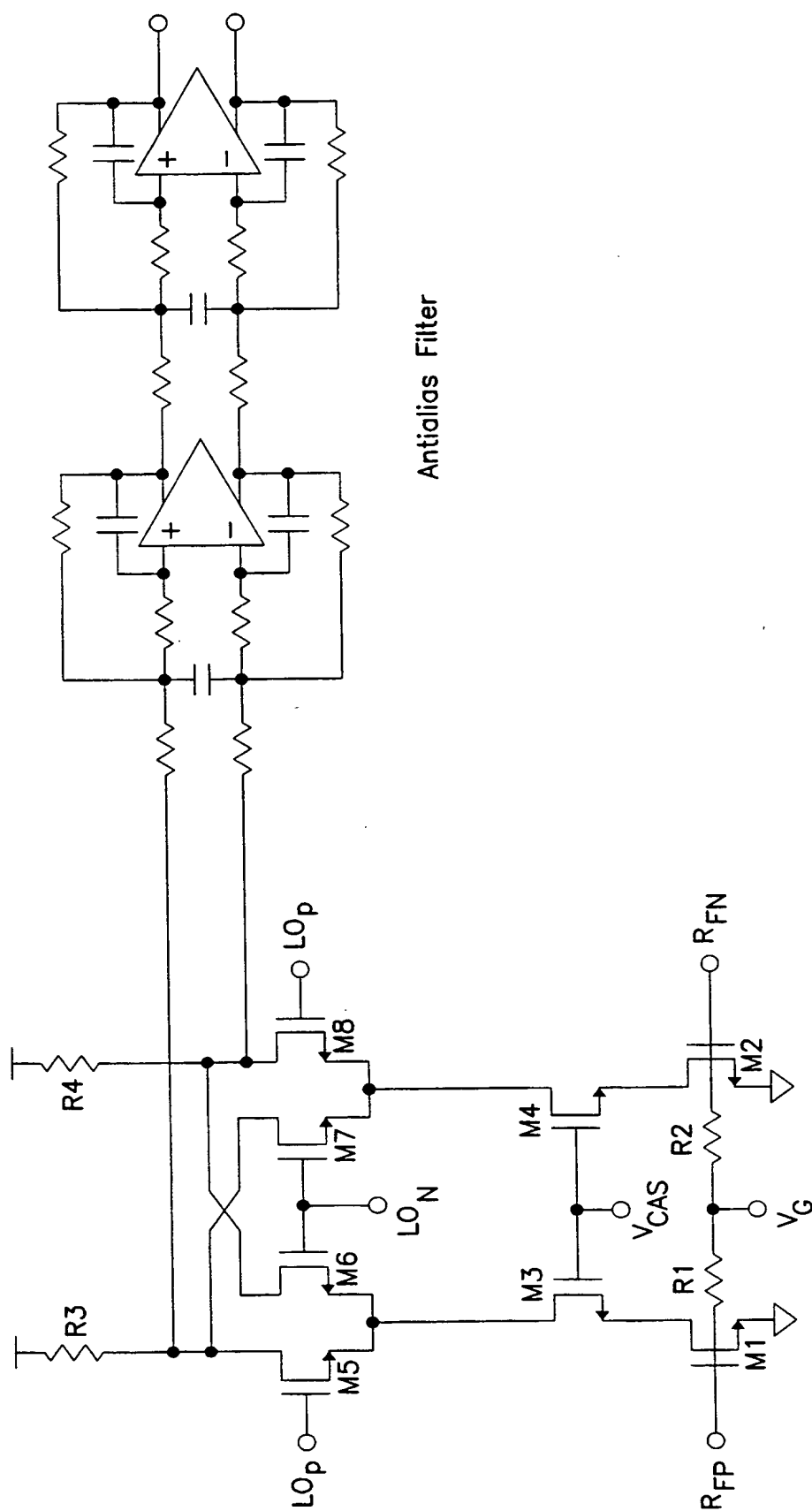


FIG. 3



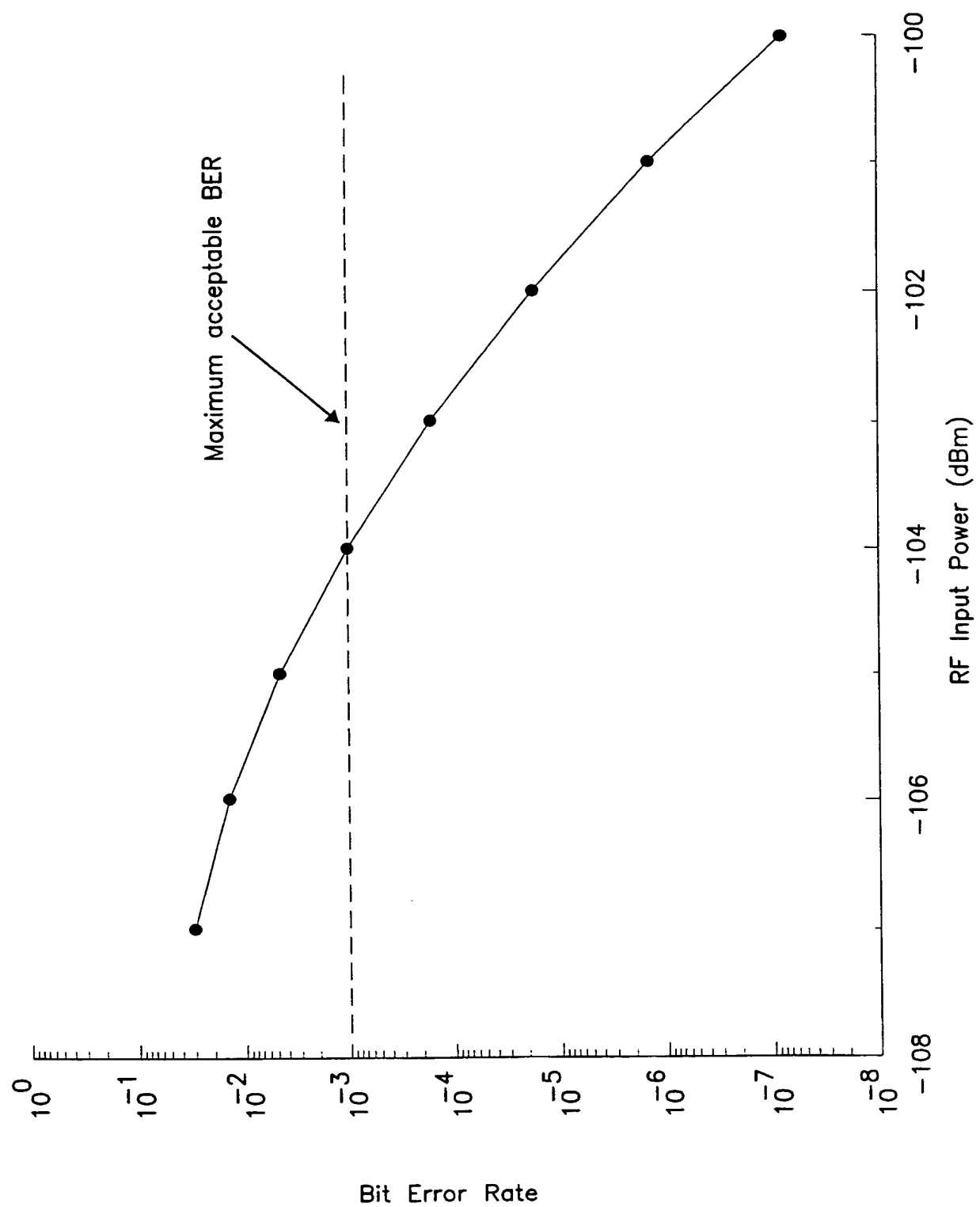


FIG. 4



FIG. 5

<u>Receiver</u>	
Sensitivity	-104dBm
Dynamic Range	110dB
Noise figure (DSB)	4.5dB
IIP2 (high gain)	+22dBm
IIP3 (high gain)	-21dBm
Selectivity (co-channel, 1.5MHz, 3MHz)	3dB, 23dB, 57dB
Blocking (4.5MHz)	67dB
Power dissipation (3.3V)	525mW
<u>Transmitter</u>	
Output power (into 50 $\Omega$ )	2, 8, 14, 20dBm
Bandwidth	1.5MHz
Modulation accuracy	$\pm 1\%$
Power dissipation (3.3V, 2dBm)	254mW
<u>General</u>	
Technology	0.6- $\mu$ m 2P3M CMOS
Die area	5.4mm x 6.7mm

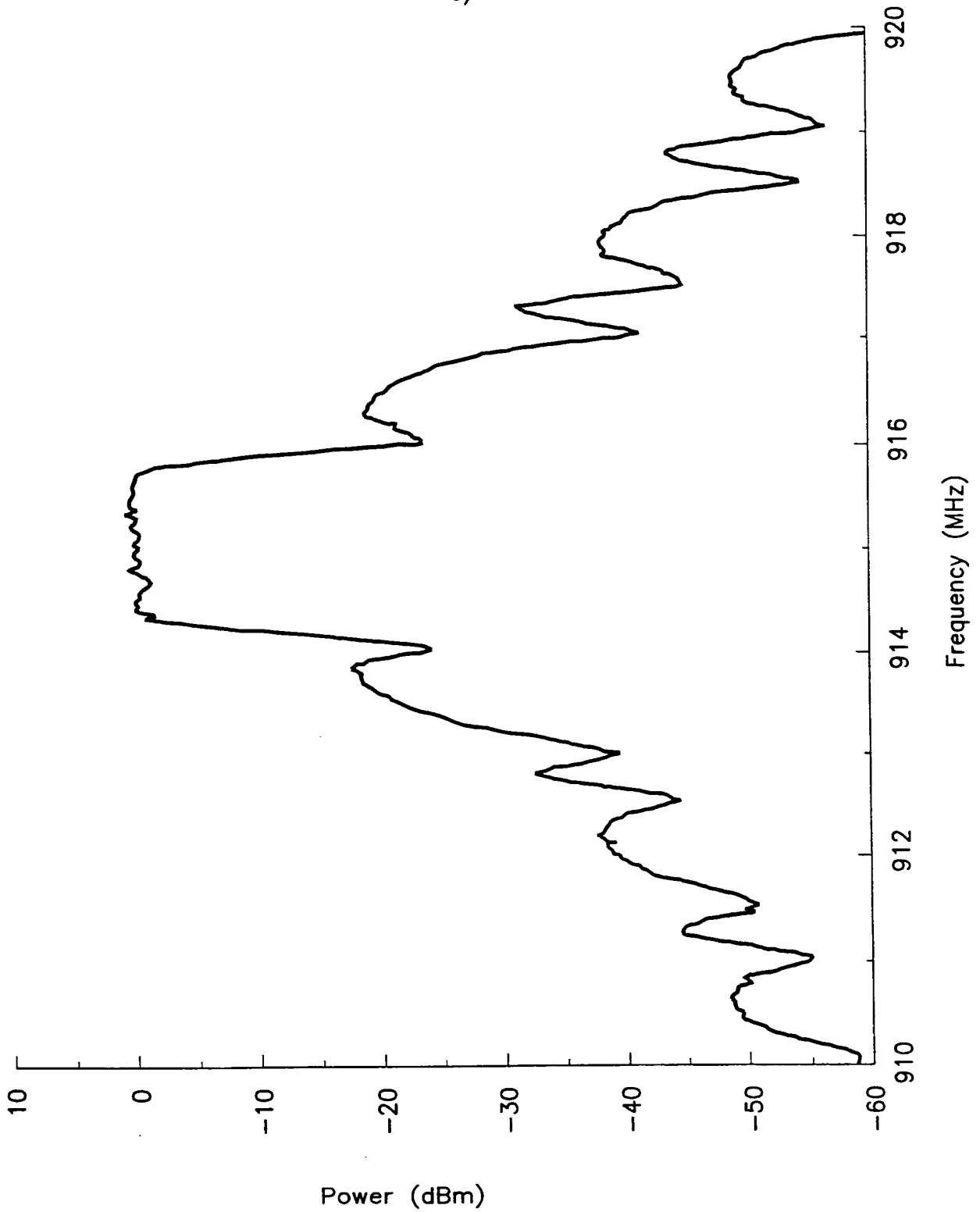
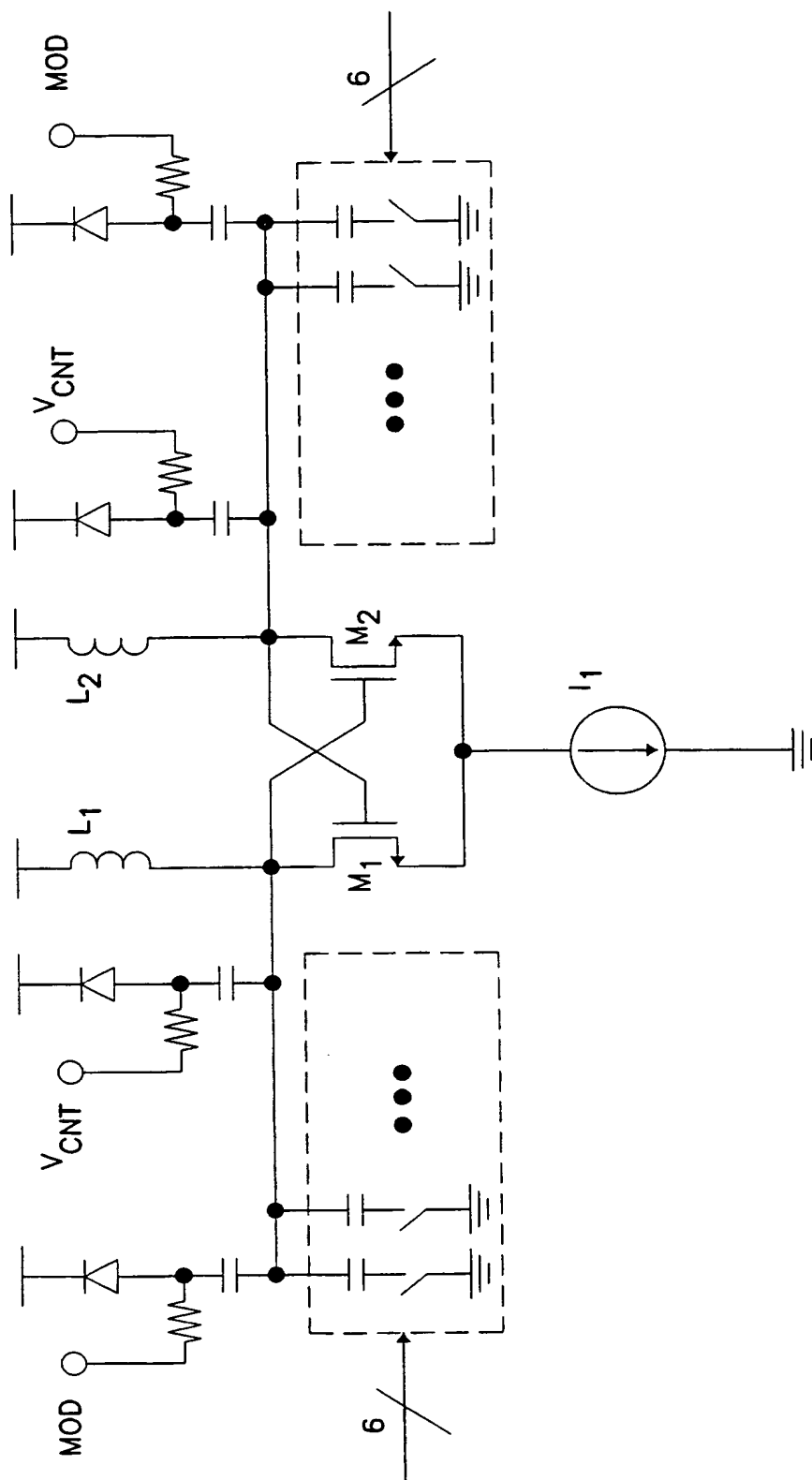


FIG. 6

FIG. 7



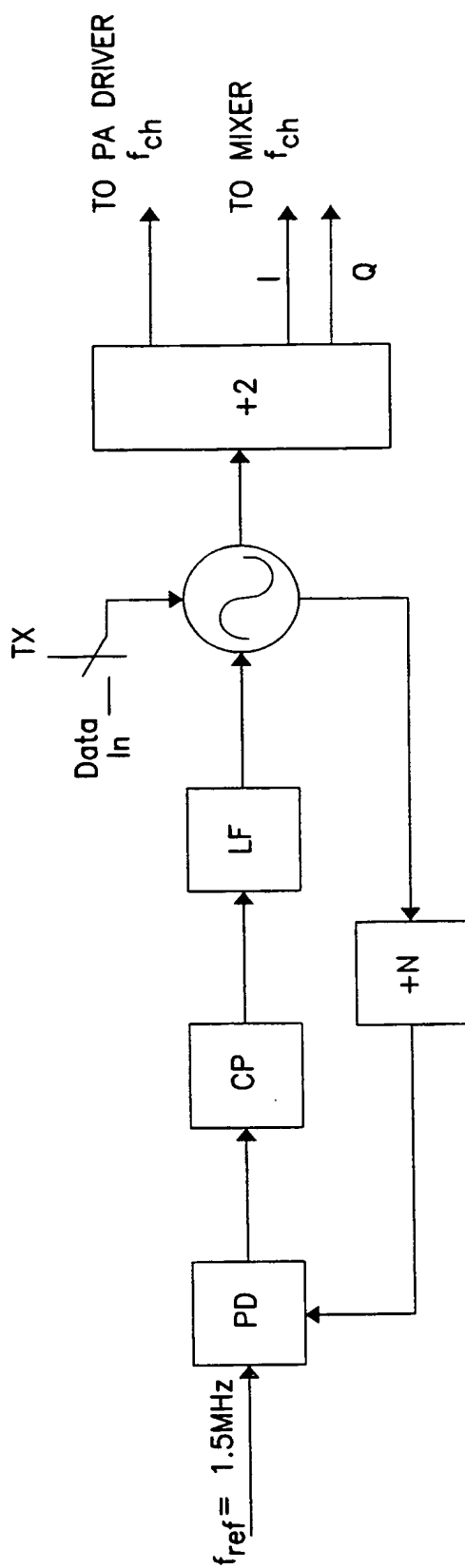


FIG. 8

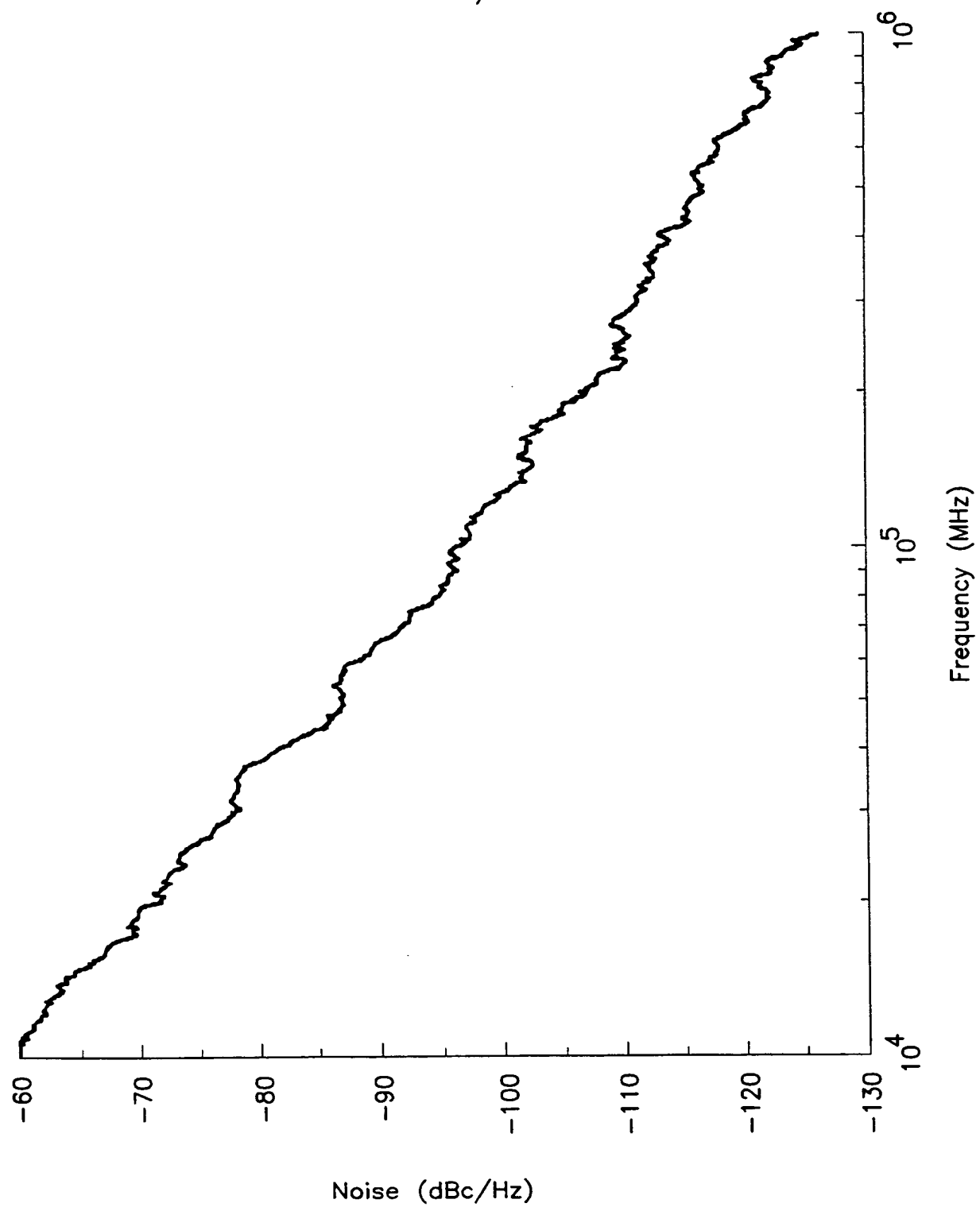


FIG. 9

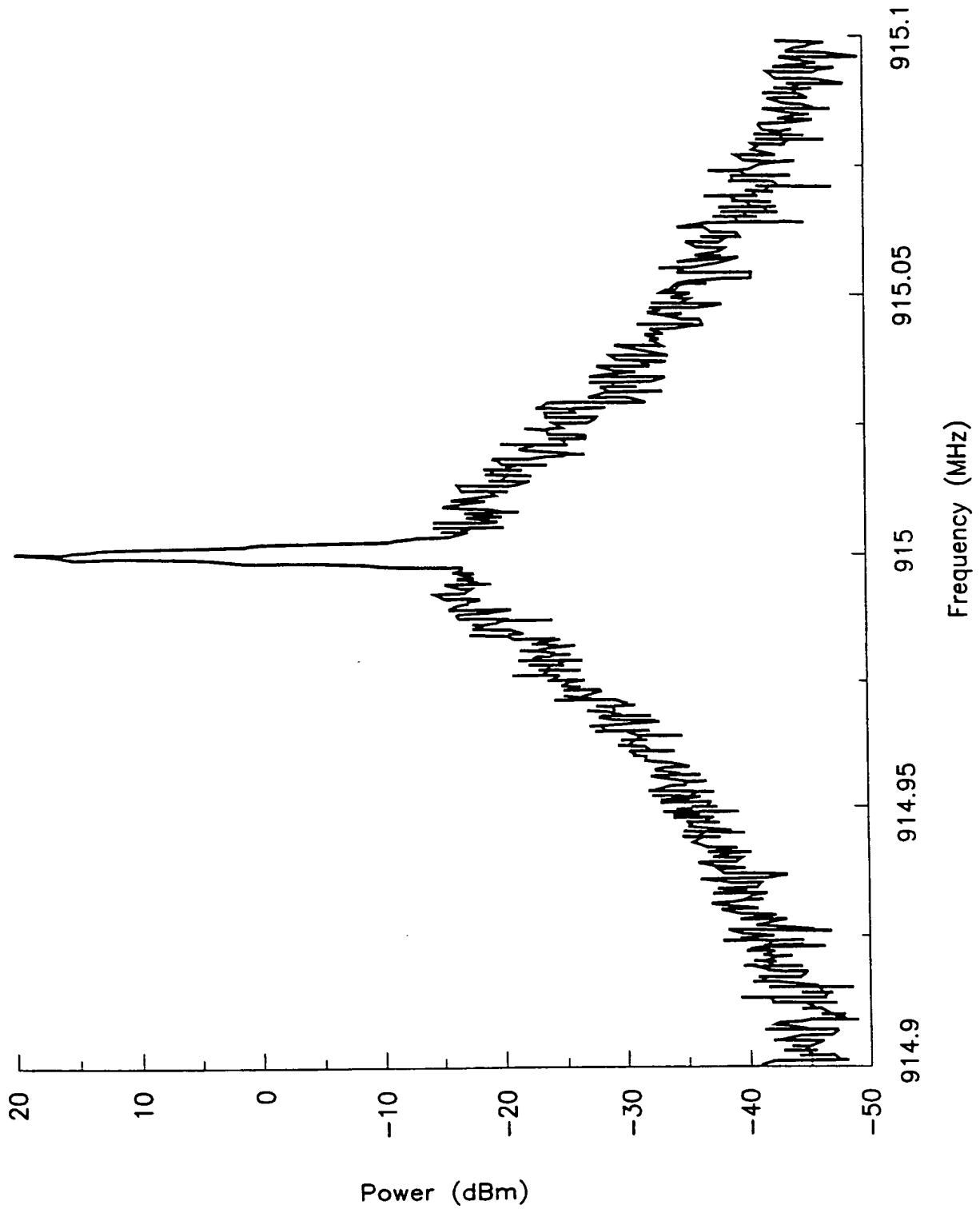


FIG. 10

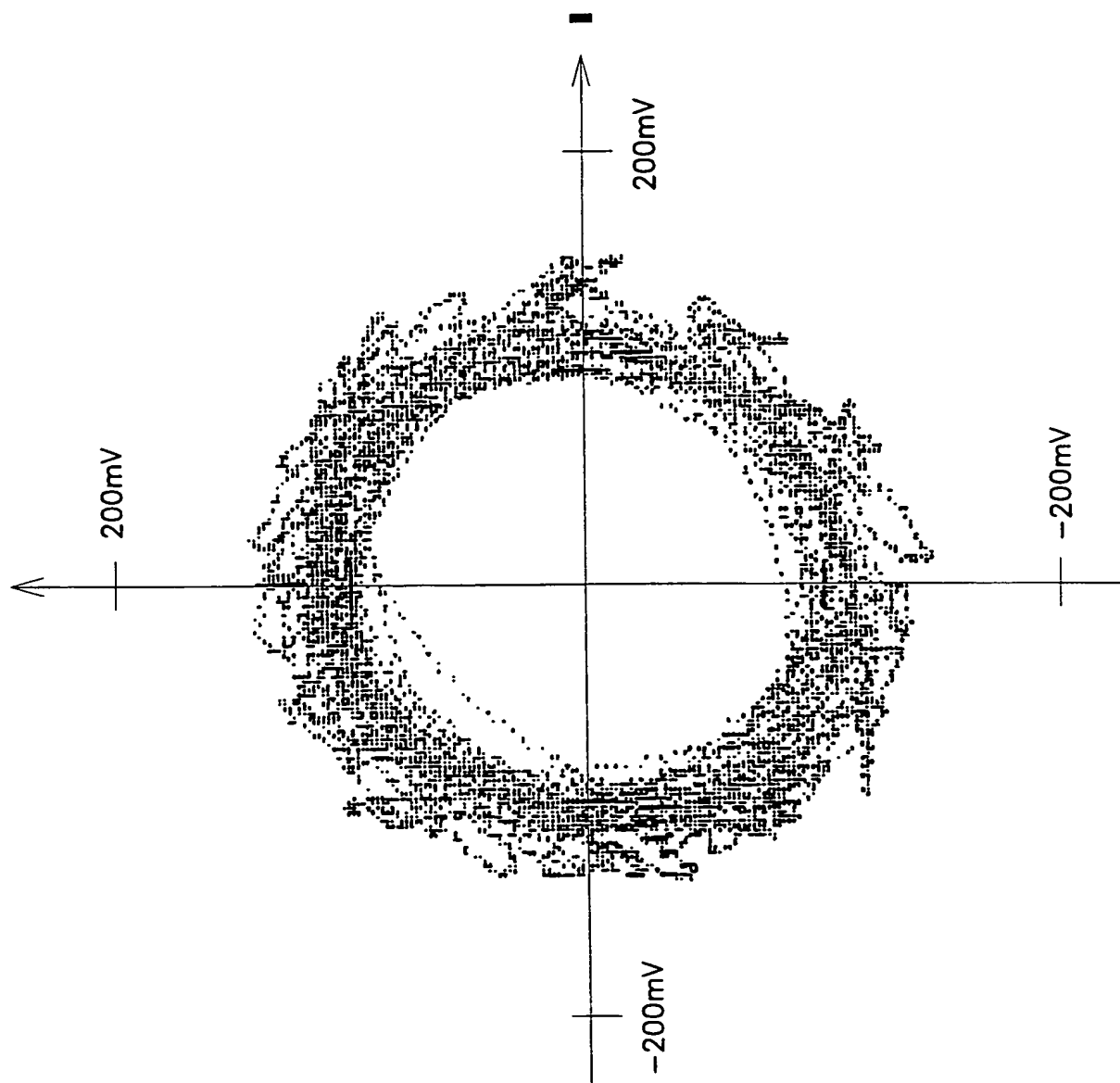
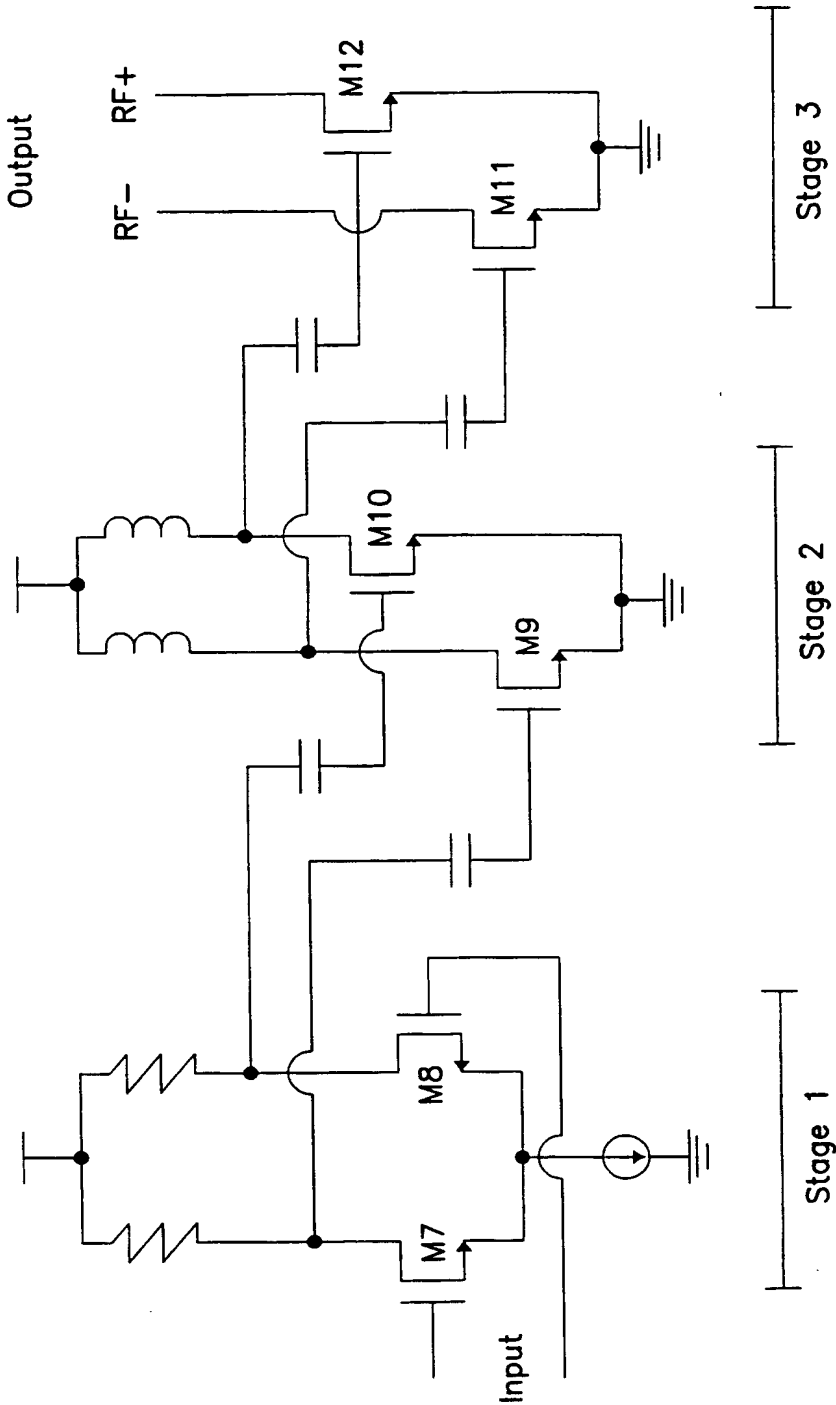


FIG. 11

FIG. 12





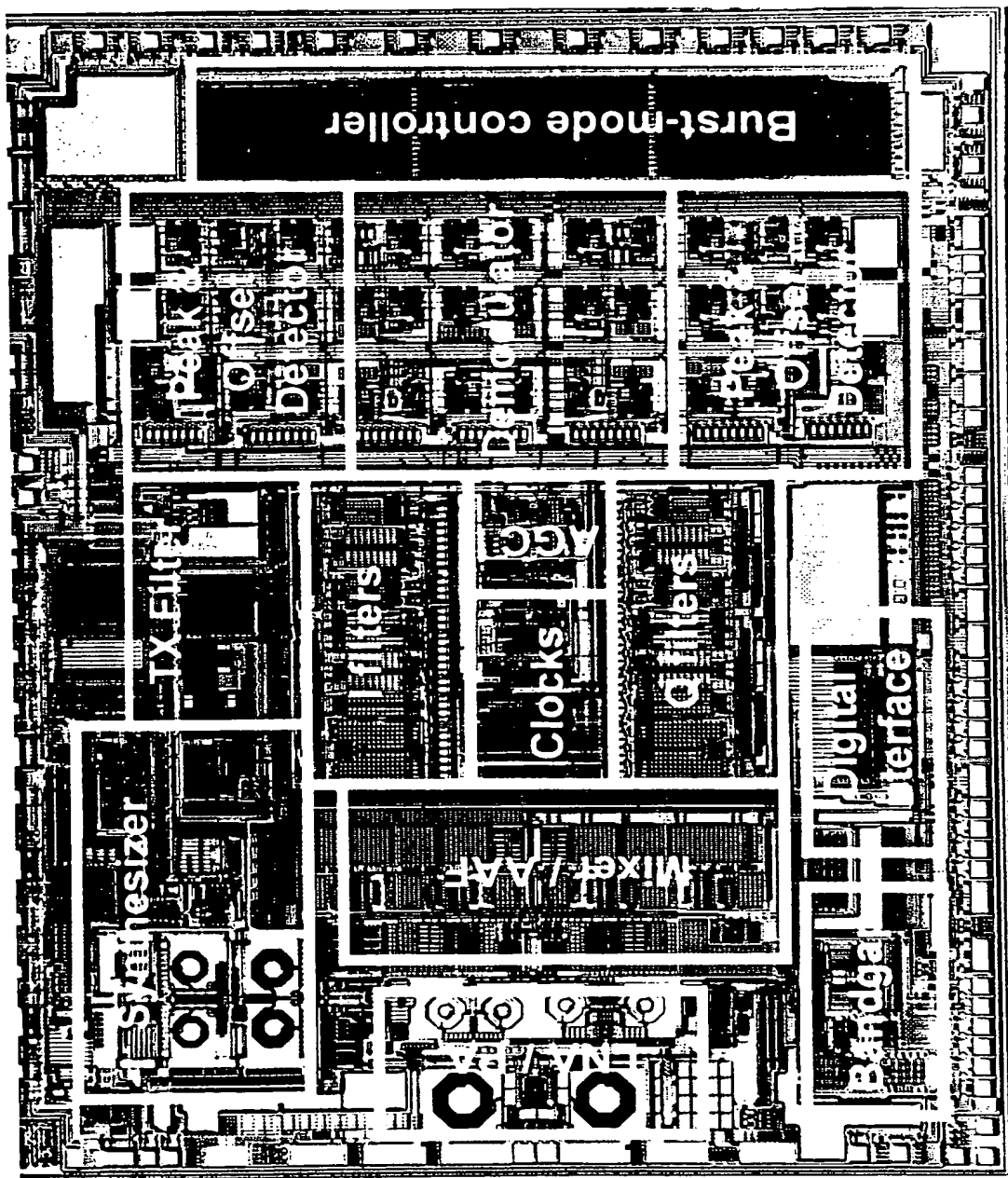


FIG. 13

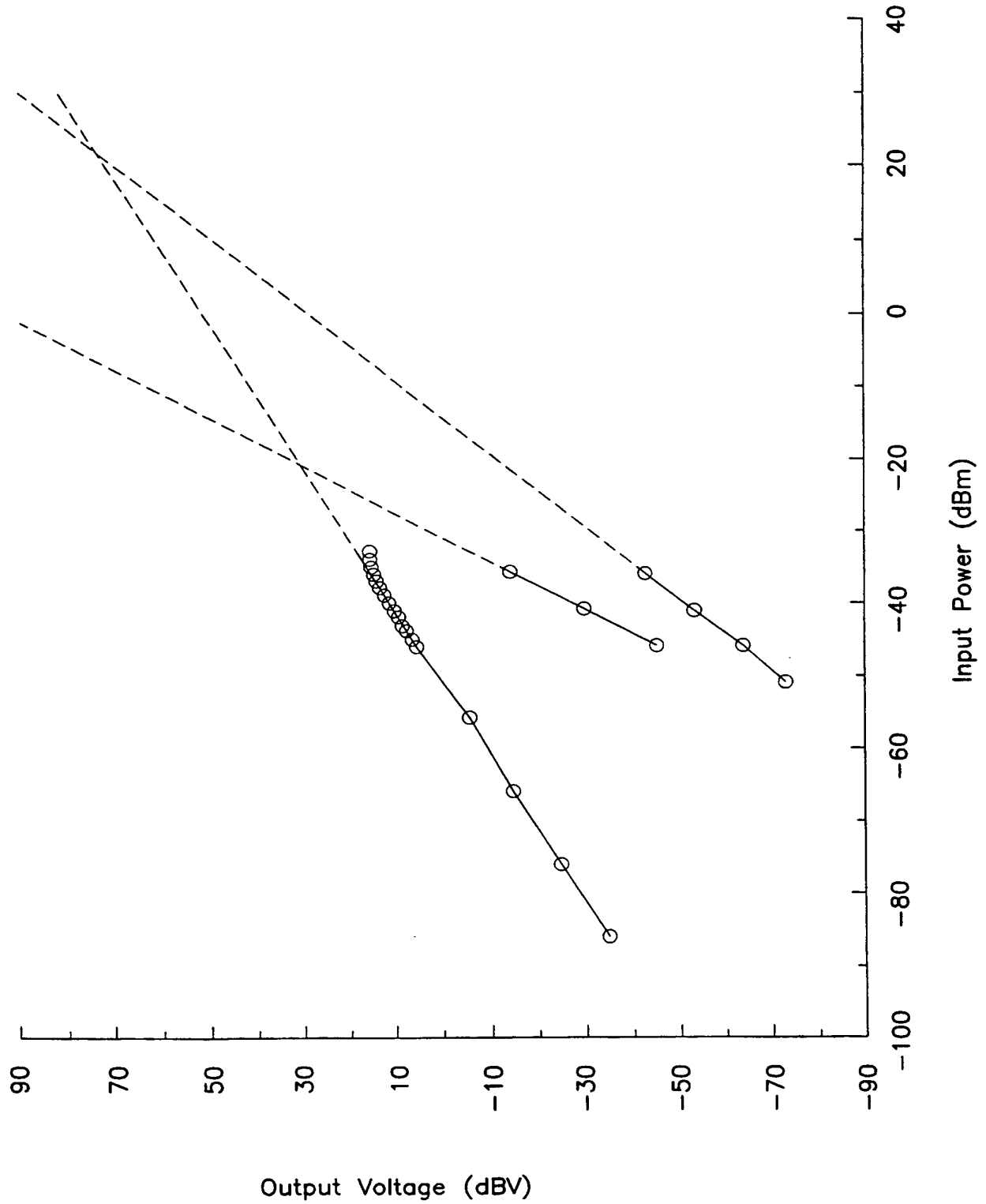


FIG. 14

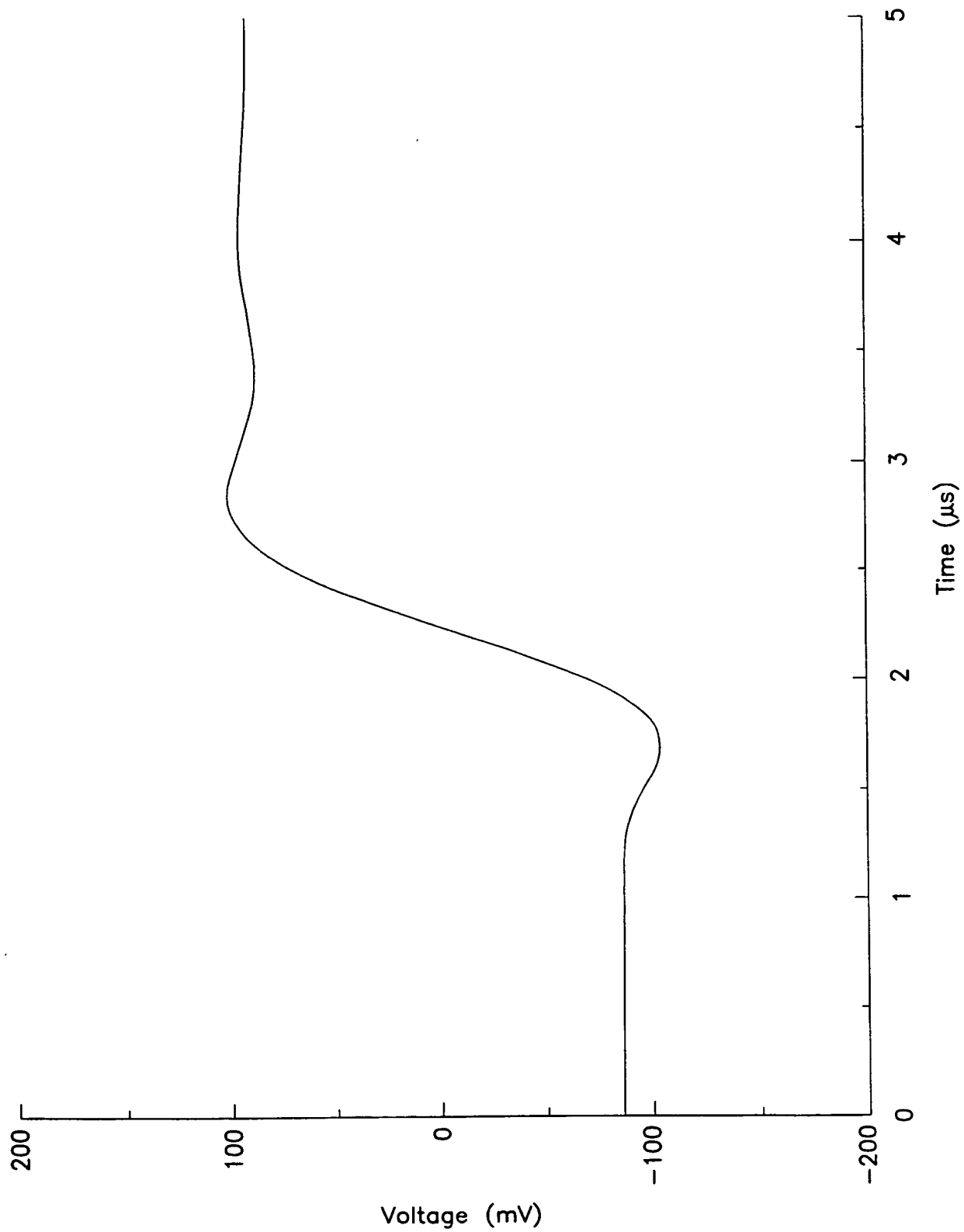
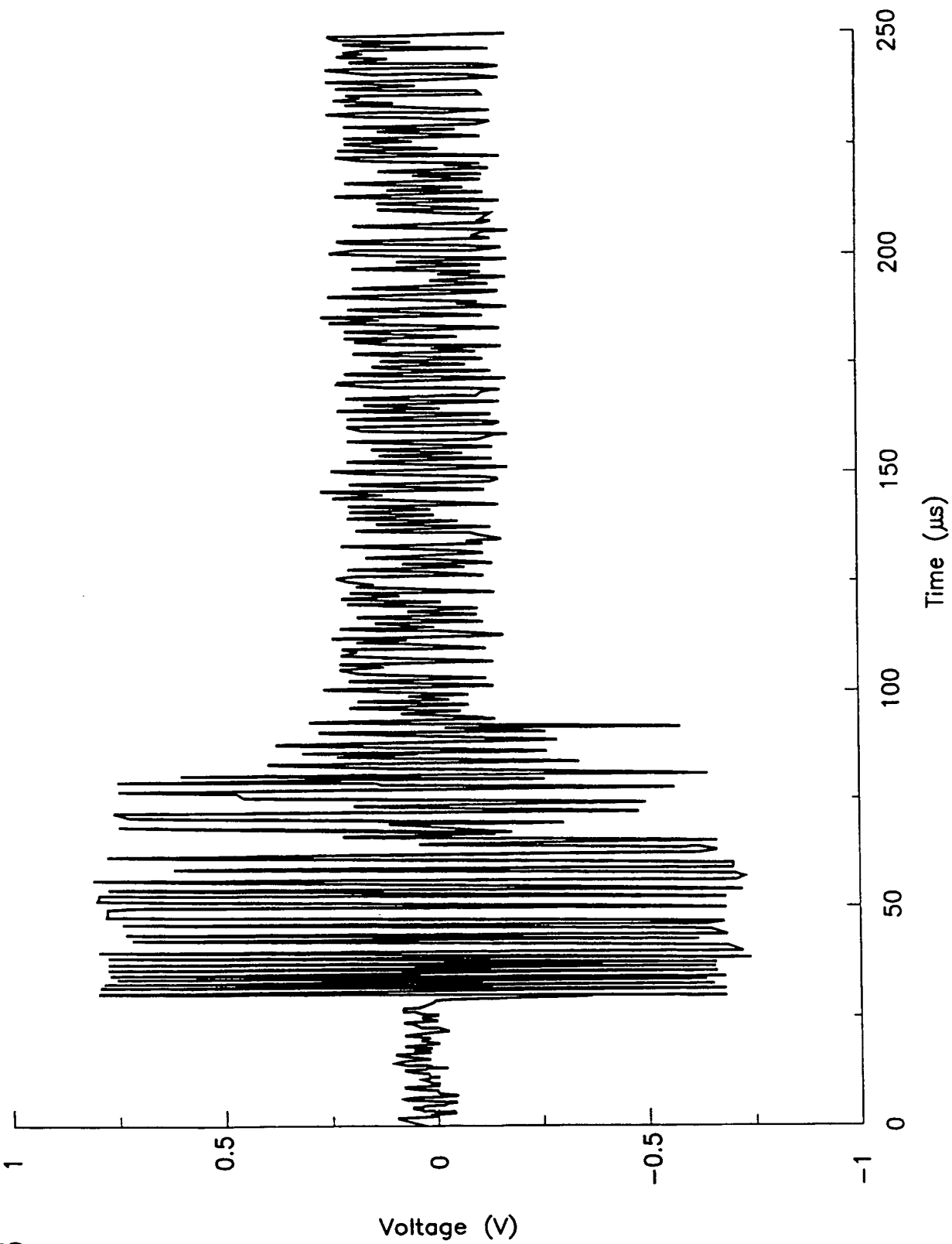


FIG. 15

FIG. 16



# INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 99/20792

**A. CLASSIFICATION OF SUBJECT MATTER**  
 IPC 7 H04B1/30 H04B1/40

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 5 414 736 A (HASEGAWA MAKOTO ET AL) 9 May 1995 (1995-05-09) abstract column 1, line 1 -column 8, line 42 figure 19	5,6 1
A	US 5 757 921 A (OKANOBU TAIWA ET AL) 26 May 1998 (1998-05-26) abstract column 2, line 65 -column 4, line 19 figure 3 figure 4	1,4-6
A	US 5 355 524 A (HIGGINS JR ROBERT J) 11 October 1994 (1994-10-11) abstract figure 2 column 1, line 65 -column 2, line 60	1-3

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

29 November 1999

Date of mailing of the international search report

03/12/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
 Fax: (+31-70) 340-3018

Authorized officer

Lindhardt, U

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/20792

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5414736 A	09-05-1995	JP 5048660 A	26-02-1993
		JP 2692440 B	17-12-1997
		JP 5048661 A	26-02-1993
		JP 5091151 A	09-04-1993
		EP 0527469 A	17-02-1993
		EP 0887978 A	30-12-1998
US 5757921 A	26-05-1998	JP 8265211 A	11-10-1996
		GB 2299226 A, B	25-09-1996
US 5355524 A	11-10-1994	W0 9314573 A	22-07-1993